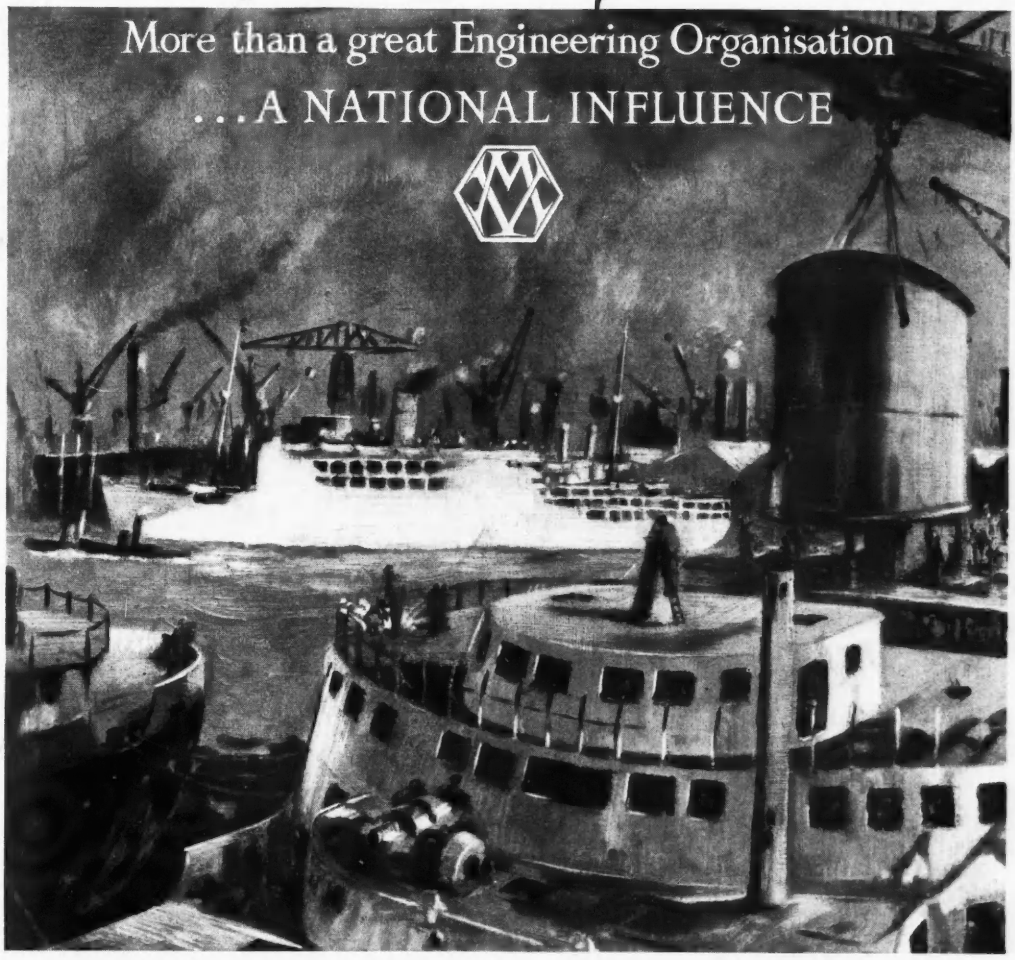
The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XII No. 8. AUGUST, 1951



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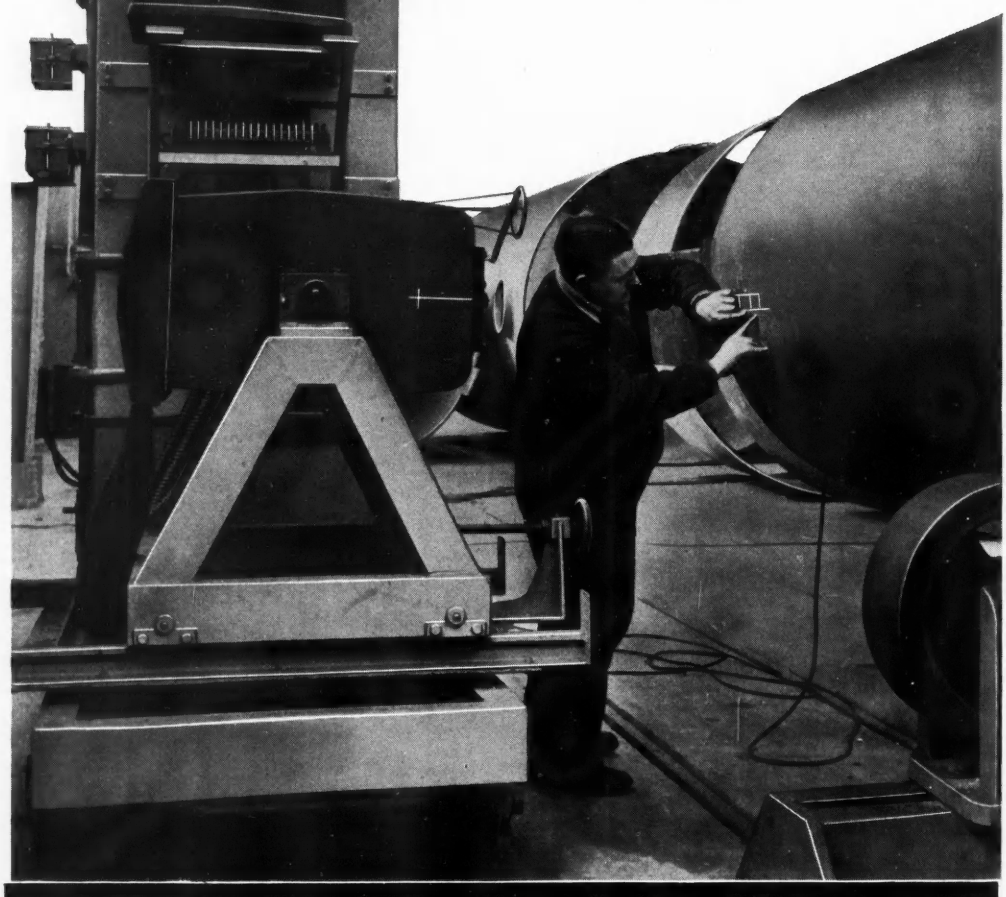

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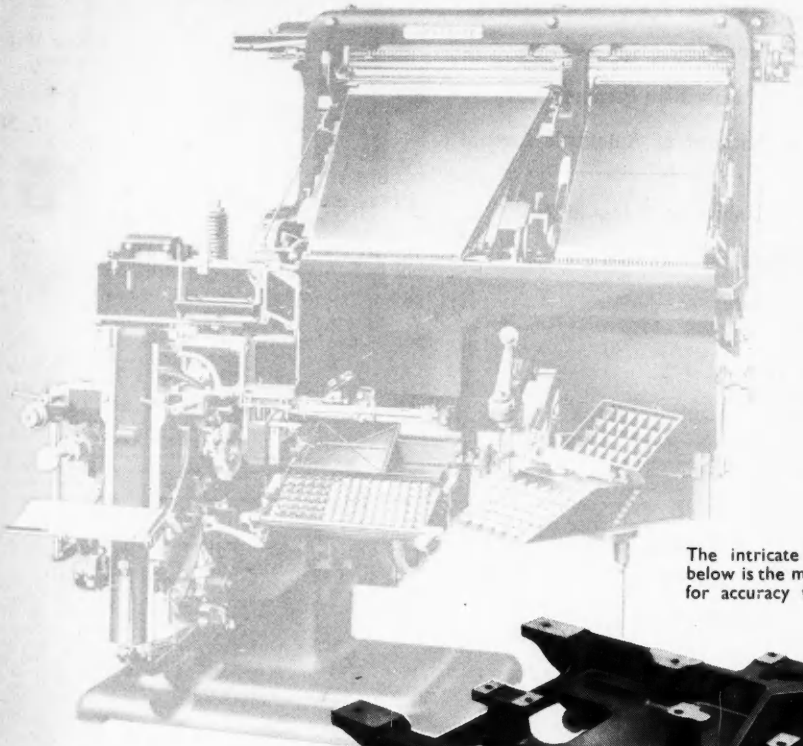

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *STRESS CORROSION*

The outstanding feature of stress corrosion is that while the amount of metal actually corroded may be small, the damage is quite out of proportion. Unlike corrosion fatigue, the occurrence of stress corrosion is conditional upon the existence of zones of weakness in the metal, and more often than not these zones are intergranular in character. Stress corrosion may be caused by residual stresses, or by constraint, or it may be due to stresses arising from service conditions; and any of them may be additive. Tensile service stresses or alternating service stresses should be kept within the safe limit. By introducing compressional stresses by peening into the surface of the material, the harmful effect of service stresses of tensile nature may be counteracted. Compressional surface stresses may also be produced by nitriding. Surface treatment has been advocated for light alloys. If this is applied by means of abrasion, care must be taken that the direction of abrasion is parallel to that of the service stress; otherwise, the grooves will act as stress raisers. Aluminium-magnesium alloys should not be surface-treated prior to ageing, since this would favour the changes responsible for intergranular susceptibility. Surface treatment after ageing is less dangerous. Expert opinion is that even very slight unintentional surface treatment may suffice to set up corrosion cracking, which, once started, may penetrate through a large cross-section. This warning applies, in particular, to solution-treated material and not so much to commercial material which has received the customary heat treatment.

● *ELECTROLUMINESCENT LAMP*

The production of light by electroluminescence is based upon the principle that electrical energy is converted into light by the action of a pulsating electric field on a suitable phosphor dispersed in a dielectric. Intermediate phenomena such as gaseous discharges or cathode-ray bombardment are not involved, and no gas-tight envelope is necessary. The absence of intermediate phenomena gives this method a high degree of simplicity and flexibility, but it does not produce highly concentrated sources of light. Experimental lamps have recently been built in the shape of an electroconductive glass panel upon which a thin film of phosphor dispersed in a light transmitting dielectric is spread. This film is backed by a metallic backing. One electric terminal is connected with a metallic strip along one edge of the glass and in contact with the conducting glass, and the other terminal is connected with the metal backing. This " condenser " with electroluminescent dielectric is connected with an a.c. lighting circuit. Panels as large as two by three feet have been built and operated. The units having the greatest light output emit green light. Other colours including yellow and red have been demonstrated with the use of small panels, but are effective only when frequencies of 5,000 to 8,000 cps are applied. It is interesting to note that the lamp producing green at 60 cycles becomes blue-white at 3,000 cycles. Brightness values of at least 20 foot-lamberts have been attained in these experiments.

● *THERMOMAGNETIC GENERATOR*

Paramagnetic materials, such as iron, nickel, cobalt and certain alloys, keep the greater part of their magnetic properties up to a critical temperature known as the Curie point. Above this point, they become non-magnetic owing to loss of permeability. The Curie point for iron is 769° C, for nickel it is 360° C and for cobalt it is 1137° C. A recent invention proposes to utilise the sudden loss of magnetization at the Curie point for the construction of thermomagnetic generators, in which the flux in a magnetic circuit or armature is suddenly and rhythmically changed by a thermomagnetic interruptor. The latter consists of an armature section which is alternately heated and cooled above and below the Curie point. The corresponding rhythmic fluctuations in magnetization induce an alternating electric current in an armature winding. In order to produce sufficiently rapid temperature fluctuations, the magnetic flux produced, e.g., by permanent magnets, is passed through interruptors of laminated design with flow passages between the laminae, which may be as thin as 0·1 mm. Heating and cooling liquids would be made to oscillate alternately at high speed through the passages. In order to widen the useful temperature range of heating and cooling liquid, these would be passed through successively arranged lamellae with a very wide range of Curie points. The possible application of these proposals to atomic power plants might perhaps be considered.

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● *NEW AUTOMATIC CONTROL PRINCIPLE*

In automatic control technique, the deflection of, or interference with, fluid jets by the mechanical action of the sensing or measuring element is a well-known means of producing a control impulse, which is usually of the hydraulic type and which is magnified in a hydraulic relay system. A recent invention envisages using a stationary jet nozzle and producing the deflection of the fluid jet by electromagnetic force. In the proposed system, the electromagnetic effect is realised by employing a liquid which contains very fine iron powder in suspension, and by passing the jet between and at right-angles to the poles of an electromagnet, the winding of which is passed by the electric current, the changes in intensity of which are to be translated into hydraulic control impulses. This system is claimed to be highly sensitive to variations in the strength of the electromagnetic field produced. In order to increase further the sensitivity of the device, the liquid jet is passed between the poles of a permanent magnet before entering the electromagnetically produced field, and after it has passed the latter, the jet is made to traverse the field of an electromagnet excited by alternating current which removes any remanent magnetism that may be present. Considering that the degree of deflection produced will also be governed by the volume percentage of iron powder present in the liquid, it would appear necessary to ensure a very high degree of constancy of iron content in the liquid if a high degree of accuracy of control action is to be achieved.

● *STRESS MEASUREMENT BY MAGNETOSTRICTION*

The phenomenon that magnetization of a magnetic body produces changes in its dimensions is well known for its employment in ultrasonic generators. Less well known is another magnetostrictive phenomenon called the "Villari effect," whereby a longitudinal deformation of the material leads to a change in its magnetic permeability. This effect is now being utilized in a number of stress measuring devices recently placed on the market. The sensitive element in these instruments consists of two magnetic cores, only one of which is subjected to the stresses to be measured, while both cores are subjected to an alternating magnetic field produced by a primary coil. Secondary coils are fitted to both cores, and any magnetic unbalance produced by the stressed core will be manifested by a difference in the voltages produced in the two secondary windings. This system is so sensitive that no electronic amplification is required. Instruments of very great sensitivity and accuracy have been designed on this basis. Thus, for instance, pressure gauges have been constructed which are suitable for the measurement of liquid pressures up to 200 atmospheres. A special instrument for the simultaneous indication of vacua and pressures has been developed, which should prove useful in the testing of internal combustion engines. A flowmeter has also been developed, in which a blade of metal is immersed in the fluid to be measured and the stress produced in the blade by the dynamic pressure of the flow stream is transmitted to the magnetic test piece.

● *TRANSFORMER OIL DETERIORATION BY VIBRATIONS*

A recent investigation of magnetostrictive phenomena in transformers draws attention to the fact that owing to these effects, vibrations both in the sonic and ultrasonic ranges are produced, which may be responsible for the deterioration of transformer oil in power transformers. It has, of course, long been known that such vibrations are capable of producing chemical changes in liquids. It appears that hydro-carbons containing traces of water are particularly susceptible in this respect. Thus, for instance, carbon tetrachloride is not affected by vibrations, even of very high intensity, when it is completely free of water, but chlorine is released even with very small vibration intensities if traces of water are present. It therefore appears reasonable to argue that with the presence of water in transformer oils, vibratory effects may be the cause of chemical reactions observed in practice. It is also significant that the oil of alternating current oil-filled cables appears to be prone to chemical reactions of the type encountered in transformers, while direct current cables are free from such symptoms. The frequency of sound vibrations in a.c. cables will be twice the electrical frequency, and while the presence and nature of chemical reactions attributable to vibrations require further clarification, there is no doubt that sound vibrations cause the release of dissolved and adsorbed gases from the oil.

● *LIQUID OZONE TECHNIQUE*

In view of the potential value of ozone as a fuel for rocket propulsion, it is interesting to note that a way has been found for the safe handling of concentrated liquid ozone. Liquid ozone can be decomposed directly to oxygen when this is required in submarines and high-altitude flying. It also has its uses, of course, as an agent for water purification, air purification and bleaching. The opinion has been expressed that with regard to its use as a fuel for rockets, ozone will be much easier to handle than fluorine. As a bleaching agent, ozone is superior to chlorine, hydrogen peroxide, and other liquid bleaches, as it leaves no detrimental residue which ultimately decreases the strength of the bleached material. Ozone can readily be made by bombarding oxygen with high-speed electrons.

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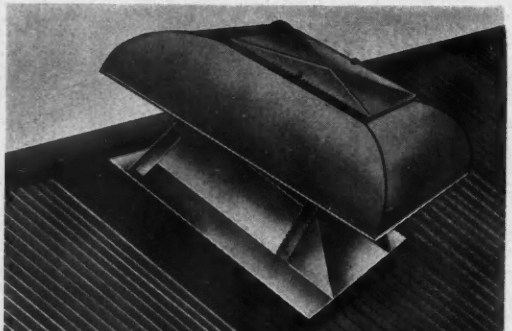

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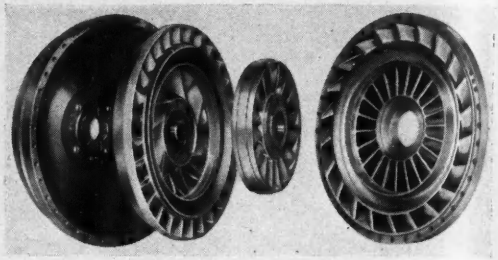

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● *ROTATING SEAL*

A new mechanical seal which rotates with the shaft on pumps, mixers, agitators and similar equipment is reported to give satisfactory service in industries where corrosive, gritting, and volatile fluids must be contained and where conventional packing has not been found suitable. The new seal consists essentially of a rotary unit which is attached to the shaft and forms a contact with a stationary sealing face, or gland, to form a bearing or ground joint. The rotary seal ring is provided with an annular recess containing an O-ring, which serves as shaft packing, against which the rounded-off annular face of the compression ring, which also rotates, is pressed by spring thrust. Provision for lubricating the gland is made. This seal is said to be especially useful where leakage must be kept to a minimum, where pressures or shaft speeds are extremely high, and where other operating conditions are severe. It is claimed that the principle of this seal makes it impossible for shafts or sleeves to become scored or worn by packing. As these seals are made of nickel and nickel-bearing alloys, they are applicable to a wide range of fluids such as are encountered in oil refining, chemical processing, distilling, and synthetic rubber production.

● *HILSCH TUBE AS SEPARATOR*

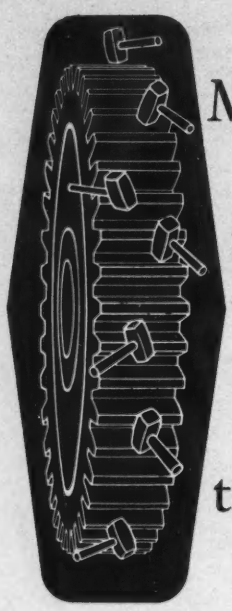
The publication some years ago in this journal of the results of tests conducted on the so-called Hilsch tube evoked considerable interest in this extraordinary device. Subsequent tests confirmed the original findings, but initial hopes that important industrial applications for this device would be discovered did not materialise. Nor has a fully satisfactory explanation of the underlying phenomenon been arrived at as yet. As readers will remember, the Hilsch tube produces two air streams of different temperatures, one colder and the other hotter than the compressed air admitted tangentially into the vortex chamber of the tube comprising the device. A recent scientific report on the tube frankly admits that any explanation of the operating principle must still be considered as hypothetical. At the same time, the report gives some important new test data which may point a way to what appears to be a promising practical application. Considering the very great peripheral velocities obtaining in the tube, it is but reasonable to expect that a separating effect will take place, so that heavier gas constituents would be thrown against the periphery and would, therefore, leave with the hot air, while lighter constituents would leave with the cold air stream subject to a minimum of centrifugal effect. Experiments first conducted with flue gas and then with atmospheric air have proved that a separating effect actually exists. Contrary to expectation, however, the heavier component tends to migrate to the colder side and not to the hotter side, that is to say, it moves against the centrifugal effect. In the case of air, this was proved by a higher content of the heavier oxygen in the cold air stream. This proves that separation must be due to a gas-kinetic effect as yet unexplained.

● *QUICK-FREEZING PROCESS*

A new patented quick-freezing process consists in spraying the foodstuff to be frozen, for instance, fish, with a stream of air of appropriate temperature which is laden with microscopic ice pellets. Owing to the particular conditions under which the air stream is produced, the ice pellets are positively electrified. In order to obtain complete and uniformly distributed coverage of the fish to be wrapped up in a cover of ice pellets, the spray process is carried out continually by passing the fish through a lock chamber, in which it is electrified with negative polarity so that it becomes progressively coated with a shell of ice. It is claimed that the wrapping action is rapidly accomplished with a minimum of heat exchange between the fish and its ice shell. After wrapping, the fish is placed in the cold storage room. The artificial hail storm, as it may be called, is produced by a plant in which compressed air delivered by a compressor is cooled in a heat exchanger and then expanded in a turbine which drives the compressor. Atomized water or brine is injected into the turbine exhaust, where the air velocity may be as high as 200 metres per second with a temperature of minus 200° C. Owing to the very minute size of the particles, the injected liquid forms instantly a dispersion of ice pellets of about one micron in diameter, which are charged electrically by friction.

● *ABRASIVE STREAM GRINDING OF CUTLERY*

In the cutlery industries, the pumicing of tea and table spoons and similar pieces of irregular shape has hitherto been carried out by hand and has, therefore, absorbed the largest share of the entire production time of the piece concerned. To carry out pumicing by automatic machines based on the principle of copy milling has not proved successful. A surprisingly simple solution to this difficult problem has now, however, been found. It consists in the use of a bath of abrasive material contained in a large circular tank rotating around a vertical shaft, the bath building up in the shape of a rotating ring against the wall of the tank. At a number of points near and around the periphery of the tank, stations with stationary work holders are arranged. These holders allow the work-piece to be held into the abrasive stream in a given position. Each of the holders is fully motorised so that the holder can be swung out of the abrasive stream for removing the finished piece and inserting another for pumicing. These movements are automatically timed and provide for grinding times from 14 to 49 seconds in steps



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of 7 seconds. Provision is also made for turning the piece in the abrasive stream so that it is impinged upon at varying angles, four positions of rest being allowed during each rotation of the piece. These positions are chosen in consideration of the configuration of the piece and the resulting flow conditions, and in each position the piece may be held still for a period ranging from 1 to 5 seconds. Experience has shown that this rotating abrasive bath permits the pumicing of all types of cutlery, fittings, buttons, etc., at high speed and efficiency, an excellent surface quality being obtained.

● *MAKING VERY FINE WIRE BY ELECTROPOLISHING*

In recent years, the increasing demand for ultra-fine wire for electronic valves and other purposes has resulted in a search for new production methods. Fine wire, down to 0·0003 to 0·0004 in., is usually made by drawing through a series of dies, but the manufacture of the diamond dies is a very costly and time-consuming operation. Production by chemical etching proved unsatisfactory because of its non-uniform and uncontrollable effect, and electropolishing was therefore attempted. But here again the small size of the wire led to considerable difficulties. In the case of fine wire, the surface-to-volume ratio, which is inversely proportional to the diameter, becomes so large that most of the current is carried by the solution near the point where the current enters, and very little is carried along the wire in the solution. This problem was solved by feeding the wire through the bath at a steady rate and under constant electrical conditions; this results in the production of a uniform wire diameter. It was found that by this process, stainless steel wire and wire of other metals may be reduced in diameter far below the limit possible by conventional drawing practice. The eventual fineness of the wire is determined chiefly by wire speed and polishing current, once composition, temperature and agitation of the bath are under control.

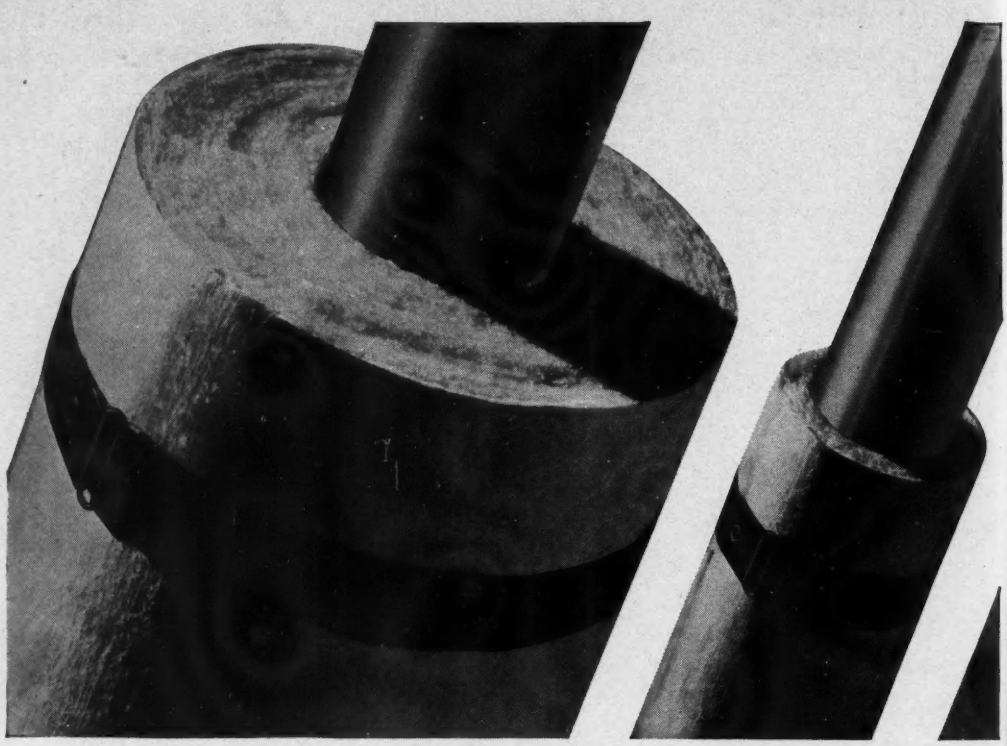
● *NEW STOP-OFF PLATING FOR SELECTIVE HARDENING*

Pure tin has been used to form a protective barrier against gas absorption from the furnace atmosphere in the selective hardening of parts requiring localized casehardening. Since tin melts at 450° F and nitriding and carbonitriding are usually carried out at 1000° F and 1350° F respectively, the tin coating will melt at these temperatures. If the coating of tin is thicker than 0·0006 in. it will run from the plated areas. To avoid this difficulty, some operators resort to a hand-sanding operation subsequent to tin plating, to reduce the plate thickness in areas which are plated too heavily. Search for a more suitable barrier metal has now led to the discovery that a co-deposited plate of 5 per cent to 15 per cent tin and 85 per cent to 95 per cent copper will form an effective barrier for nitriding gases at 1000° F. In addition, it was found that the higher melting point of the alloy plate was effective in preventing troublesome running of the stop-off medium, even up to a thickness of 0·002 in. of plate. This method is also effective in carbonitriding at 1350° F. It is reported that the method has proved satisfactory under production conditions and that at least one major American aero-engine maker uses it for all nitriding of gears and shafts. Existing sodium stannate tin plating solution can be easily converted to co-deposit copper and tin, and there is no need of a complicated dual anode system or alloy anodes. A full description of the procedure to be followed in such a conversion is given in the original source.

● *LUMINOUS MAGNETIC FLUX LINES*

The determination of the lines of magnetic flux is a problem of considerable importance in many electrical engineering problems. While two-dimensional field distribution can be determined by analytical approach and by experimental methods, the determination of three-dimensional field distribution is much more difficult to carry out, and in many cases analytical treatment is exceedingly difficult to apply. Experimental methods for the determination of local field strength by bismuth wire probes, etc., are time-consuming and cannot be applied to fields in narrow gaps and restricted spaces. It has now been found that glow discharge phenomena enable a visual reproduction of magnetic fields in space to be made. This method has proved particularly useful where fields of small dimensions have to be examined. Moreover, the method allows the examination of cyclically alternating fields to be made, and even their photographic recording is possible. It consists in placing the magnet system, or a part of it, as, e.g., two poles with an intermediate air gap, under a glass bell, which is then evacuated. By applying a moderately high voltage to the magnet system and an anode, a glow discharge is produced, which indicates magnetic lines of flux. In order to concentrate the glow discharge in the zone where the flux lines are to be studied, the entire magnet system is covered with varnish and small holes are made in the varnish film at the points where the flux lines are to be made visible. From special tests it has been concluded that the glow discharge lines represent the magnetic flux lines with satisfactory accuracy.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



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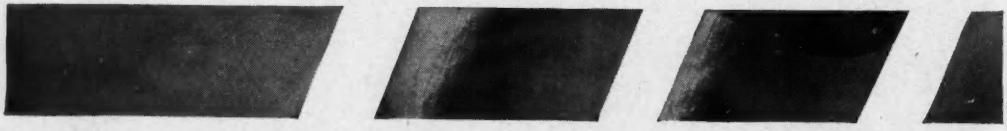

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The Borsig-Fiat Marine Diesel Engine

By F. FRÖHLICH. (From *Schiff und Hafen, Germany*, Vol. 3, No. 6, June, 1951, pp. 197-203, 13 illustrations.)

This article describes the latest trends in the development of Fiat engines. After comparing two- and four-stroke engines, it gives details of the loop-scavenge system evolved by Fiat and then outlines the design features of the single-acting engines. The use of a gas-tight partition between the cylinders and crankcase is advocated as a means of increased safety against crankcase explosions. The processing equipment installed on ships with engines operating on boiler fuel is described, and a review of operating experience with fuels of this type is given. The article includes details concerning the engine frames and the special cast-steel semi-built crankshafts developed by Fiat. Following a description of the double-acting engine, mention is made of the use of these engines as main propulsion units in ocean liners requiring a power of 50,000 hp.

THE Borsig Company, of Berlin, which has produced many hundreds of reciprocating steam engines in the past decades for ships of various countries, has expanded its programme to include the building of large-size marine diesel engines for merchant vessels. As the development of an engine of their own design would have required many years of experimental work, Borsig acquired a licence from the Fiat Co., of Turin, for the construction of large marine diesel engines. In the following lines, the design details of these Fiat engines as well as the features which make it possible for them to operate on low-cost boiler fuels will be described.

The Fiat engine is the result of continuous development work on a basic design produced forty years ago and which has never required serious alteration. Basically, the engine is of the single-acting two-stroke cycle type with simple loop scavenging and self-operating scavenge valves; the frame has a special partition between the cylinders and the crankcase.

TWO-STROKE CYCLE

The approximate production survey given in Fig. 1 shows that when Fiat first developed its two-stroke cycle large-size diesel engines with a crosshead arrangement, most manufacturers were still producing four-stroke cycle engines. To-day, the arguments which lasted over two decades have long been settled and it is generally recognised that for rated powers above 2000 hp the four-stroke has been completely supplanted by the two-stroke cycle engine with its more favourable features as regards power and weight. The engine type presented much more difficult problems in design and construction. Shipowners had to be convinced of the advantages of an engine that was different from those which conventional practice recommended at that time. Moreover, commercial success was a necessary requirement for further technical progress, since it is only in engines which operate under normal sea-going conditions that the practical experience can be gained which serves to improve a machine still further and bring it to a high degree of development.

LOOP SCAVENGING

It is essential for the efficiency of the two-stroke cycle that the cylinders be thoroughly scavenged at the end of the expansion stroke. To achieve this, the dimensions and design of the inlet ports must be such that the scavenge air will not merely bore through the burnt gases and reach the exhaust ports by the shortest path. The air stream must be directed in such a way that it will scavenge the entire cylinder and evacuate the exhaust products without mixing with these to an appreciable extent. This requires low flow velocities, small pressure differences, and correspondingly large-size passages.

In spite of the increased thermal and dynamic difficulties which are associated with loop scavenging and which required extensive tests, the Fiat Co. decided in favour of loop scavenging. In the transverse scavenging arrangement adopted, the air flows as indicated in Fig. 2. The exhaust products leave the cylinder, and the scavenge air enters the cylinder through oppositely situated slots in the liner, which are uncovered by the piston near the bottom dead centre position.

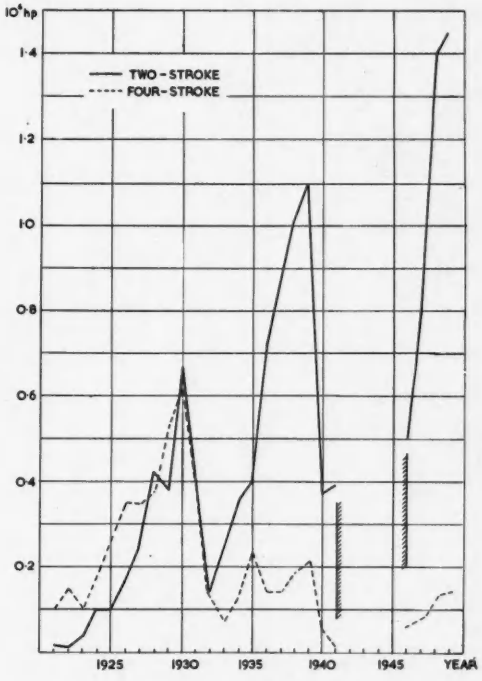


Fig. 1. Production of marine diesel engines of the two and four-stroke cycle types during the last 30 years.

In comparison with uniflow scavenging, which is theoretically more favourable, more easily achieved, and covers the entire space in the cylinder, transverse loop scavenging has the immediate advantage of not requiring auxiliary timing devices for the exhaust, such as sleeve valves moving towards the piston, or large valves in the upper cylinder cover. An additional important facility with transverse scavenging is that, in overhauls, no timing devices or hot exhaust pipes have to be taken away when it is necessary to remove the cylinder cover without undue loss of time in order to examine the piston body.

The essential features of the Fiat transverse scavenge arrangement are shown in Fig. 2. With this system, developed as a result of numerous tests with glass cylinder models, efficient scavenging is obtained even with engines having an extremely long stroke. The inlet air ports are inclined, in the horizontal plane, in such a way that the various air streams will be approximately directed towards the centre of gravity of the semi-circle of the scavenge side, instead of towards the centre of the cylinder. The air ports also have a steep slope upwards, in the vertical plane. In this manner, the air streams will converge and rise on one side only of the cylinder, the other side being left free for the downward flow. Moreover, the charging of the cylinder with fresh air is further improved by the fact that the inlet channels are extended upwards. During the up-stroke of the piston, the upper port area then serves for the compression of the cylinder contents to the required scavenge pressure. Self-acting valves prevent any return flow of the exhaust into the scavenge pipes during the downward motion of the piston.

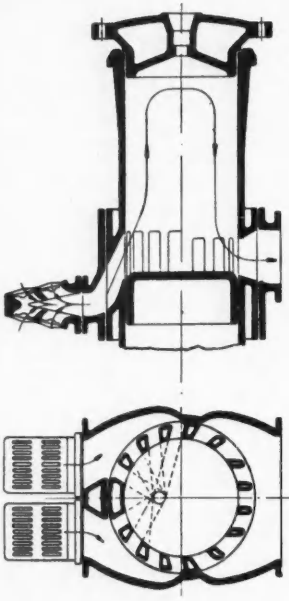


Fig. 2. **Transverse loop scavenging of a single-acting engine.**

For double-acting two-stroke cycle engines, a new scavenge system has been developed (see Fig. 3). In order to save in height, instead of having separate valves for the top and bottom portions of the cylinder, a system consisting of a double series of centrally situated inlet ports has been designed, with profiles similar to those previously described. The ports communicate with a common supply pipe provided with non-return valves, which open twice during each revolution, releasing air alternately to the ports of the upper and lower cylinder sections. Between the central inlet ports and the exhaust ports, two further horizontal series of ports are arranged in opposite positions. These ports converge towards the front part of the cylinder, and their air streams combine with the upwardly directed streams from the central inlet ports. These additional inlet ports are directly connected to the air chamber without non-return valves, and their height is less than that of the exhaust ports by an amount which ensures that, at the instant of admission, the cylinder pressure will be definitely lower than that of the scavenge air.

With this arrangement, the reduction obtained in the heights of the cylinder and piston is about 40 per cent of the stroke for slow-speed engines and about 60 per cent for higher-speed engines, the overall height of the engine and the headroom required for vertical removal of the piston being reduced correspondingly. Furthermore, the arrangement results in a considerable reduction of the number of scavenge valves and also lowers the manufacturing costs.

DESIGN FEATURES OF THE SINGLE-ACTING ENGINE (Fig. 4)

The subdivided cast-iron bedplate framework is high and of rigid construction. It is fitted with countersunk main bearings which carry the sturdy semi-fabricated crankshaft. The cast-iron columns are also mounted on the bedplate and bolted together. The sliding paths are built on one side of these columns.

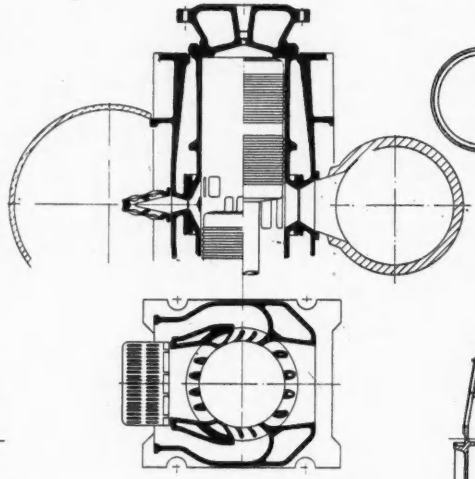


Fig. 3. **Transverse scavenging of a double-acting engine.**

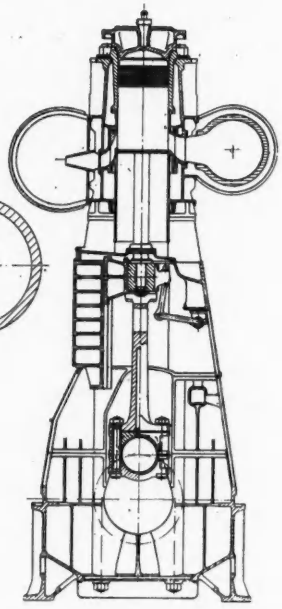


Fig. 4. **Sectional view of a single-acting marine diesel engine, constructed in 1950.**

On the opposite side, a removable intermediate member permits the removal of the crankshaft without dismantling the engine. The cast-iron cylinders are separately cast. They are bolted together so as to form one large block and anchored to the bedplate by powerful tie-bolts.

The liners consist of a steel upper portion containing

press-fitted special cast-iron liners extending as far as the piston rings. This upper portion of the liner is bolted to the cylinder from above with the cast-steel cylinder head, and from below with the lower portion of the liner. The lower portion is centred in the cylinder block at the level of the exhaust and scavenge slots. Water cooling is arranged around the air passages and the liner is cooled over its entire height. The injection valve is arranged at the centre of the cylinder cover, on which the exhaust valve and safety valve are also fitted. All the crankthrow bearings are pressure-lubricated, oil being supplied to the crosshead together with the oil required for piston cooling. The oil first flows through the crosshead bearings and then reaches the big-end bearing through a passage in the connecting rod. Neither the big-end bearings nor the separately lubricated main bearings have the previously conventional annual oil grooves, which subdivide the bearing shell into two bearing surfaces and thus reduce the load-carrying capacity to a considerable extent. The scavenge pump consists of two double-acting cylinders arranged one above the other, with pistons driven by an auxiliary crank connected to the free end of the main crankshaft.

USE OF LOW-GRADE FUELS

The fact that Italy had no coalmines or petroleum resources was not without influence on the policy of the Fiat Co. All its engines of medium and high power ratings are developed so that thay can operate, as far as possible, on any liquid fuels, even of the lowest grade and hence the cheapest, that happen to be available. As far back as the period before 1914, Fiat built for the Italian Navy two-stroke cycle engines of medium speed which operated satisfactorily on dark-coloured fuels with a specific gravity of about 0·9-0·92.

Partition between cylinders and crankcase : At the end of the first world war, Fiat was confronted with the problem of adapting its newly-developed large-size diesel engines to the use of heating oils, i.e., fuel oils. It was found expedient to separate the crankcase completely from the cylinders by means of a partition. It is a known fact that solid particles and heavy constituents of residual products will pass over the piston rings and piston and reach the lubricating oil when the pistons are in communication with the crankcase.* Experience indicates that, even with high-quality scraper rings, it is extremely difficult to avoid this permanently. It was therefore considered necessary to incorporate the partition in the engines, in order to avoid the ingress of impurities into the lubricating oils, in spite of the increase in engine height and production costs.

In various other engine designs, a closed space is provided under the cylinders, which serves as a scavenge air receiver.† This reduces the danger of impurities entering the lubricating oil, but requires frequent cleaning of the air receiver and of the valves of the scavenge pump. This is somewhat laborious, but it is also necessary in order to eliminate risks of ignition or explosion occurring as a result of the accumulation of residual products. As, moreover, this space is under a fluctuating pressure, it is difficult to prevent combustion products reaching the crankcase *via* the stuffing box of the connecting rod and thus finding their way into the engine oil.

Operating experience with pneumatic fuel injection. The first difficulties to be overcome in using heating oils were relatively small, since the oils were not of such a low grade as those subsequently put on the market. Furthermore, the engines used at that time were of the air-blast injection type, and the forces due to the expansion of the air blast were sufficient to facilitate the atomisation of even the more viscous fuels. The first practical use of boiler fuel on a large scale took place on four motor-vessels of the " Barbarigo " type in 1928. These ships were driven by a single-acting eight-cylinder two-stroke cycle engine with a bore of 750 mm and a normal rated power of 4440 shp at 115 rpm. For twelve years, up to the date of their sinking in 1941, they operated on heating fuels of naturally varying quality, depending on the particualr port at which they happened to be refuelling. Many types of fuel oils were tested, and Table I indicates the values of two oils which cover the main characteristics of the various oils employed.

Before use, the heating oil was drawn from the double bottom and pumped into settling tanks at 50-60° C, where it was allowed to settle ; generally, while the oil was in these tanks, a fairly large quantity of salt water separated from it. The fuel oil was then heated to a temperature of 70-80° C and pumped into the centrifugal purifier, after which it was passed into the container for the day's consumption. From this it went through heated pipes, in which it was heated to 60-70° C if necessary before reaching the fuel nozzles. The atomisation pressure was 70-75 kg/cm² for normal engine operation. Owing to the large flow cross-sections used and the moderate viscosity of the heating oil, it was rarely necessary, except in the winter, to start with a cold engine using diesel fuel. During their 12 years of service, these four ships were over-hauled by the Fiat Co. who thus obtained comparative data on the behaviour of these engines with various heating oils and diesel fuel. The main difference was in the more rapid wear of the liner, attributable to insufficient refining of the boiler fuels. Instead of 0·08-0·10 mm per 1000 hours of operation, the rate of wear had increased to an average of 0·15-0·18 mm.

Operating experience with airless injection : The use of heating oils in airless injection engines presented a much more difficult problem. After systematic tests over a long period, Fiat was able to put into service several single-acting two-stroke cycle engines of large bore and relatively low speed, operating on boiler fuel.

Shortly before the second world war, the " Soc. di Navigazione Italia " became interested in the possibilities of low-grade fuels. The motor vessel " Leme " was made available for tests. This ship had been modernised in 1937-38 by replacing its old four-stroke engines with two new Fiat single-acting six-cylinder two strokes with 680 mm bore and a normal rated power of 3000 shp each at 125 rpm. It was decided to run one of these engines on " Bunker oil C " (with characteristics similar to those given in Table II) and the other on normal diesel fuel. The bunker oil C, " the worst and therefore the cheapest oil available," was allowed to settle in the tanks at a constant temperature of about 70-80° C. It was then processed in two large centrifuges at approximately 100° C and some 10 per cent of boiling water was added to it in order to dissolve the potassium chloride and to facilitate the removal of earthy and asphaltic constituents. Following this operation, the oil was led into the day's consumption tank and held by a steam-heating system at a temperature of 70-80° C. From this tank, the oil was drawn off and heated in a vapour-heater up to 105-110° C, at which temperature even the lowest-grade bunker oils have a viscosity not exceeding 5-6 Engler degrees, which is approximately that of a normal diesel fuel at about 30° C. From the vapour-heater, the fuel oil passed through a filter and then reached the fuel pump and the injection nozzle, which was cooled with fresh water and operated at a practically constant temperature of 105° C. The injection pressure was approximately 600 kg/cm² at normal loads.

The engines were started with normal fuel. After

*As, for instance, in the case of the engines of M.A.N., Doxford and Sulzer.

†Engines of this type include those of Burmeister & Wain, Götawerke, Werkspoor four-stroke with pressure-charging.

	Table I		Table II		Table III	Table IV	
Refuelling station	Suez	Suez	Colon	S. Pedro	Tuxpan	New York	New York
Type of fuel	Fuel-Oil	Bunker C	Bunker C	Bunker C	Bunker C	Bunker C	Bunker C
Origin	—	—	Venezuela	California	Mexico	U.S.A.	U.S.A.
Density at 20° C	0·942	0·983	0·987	0·977	0·954	0·993	0·993
Viscosity (Engler) at 50° C	6·25 °E	48° E	56° E	26·1° E	54° E	55° E	67° E
Higher calorific value, kcal/kg	10·145	9·816	10·270	10·150	10·330	10·255	10·236
Flash point °C	124°	144°	134°	126°	145°	136°	144°
Sulphur %	0·80	1·20	1·58	1·45	3·63	2·63	2·66
Ash %	0·05	0·06	0·2	0·18	0·16	0·14	0·15
Conradson %	8·27	13·67	—	—	13·97	13·75	14·73
Hard asphalt %	4·16	11·22	—	—	7·84	10·0	10·10

the temperature of the pumps and the piping had reached 70-80° C in 5-6 minutes, engine operation was switched over to bunker oil C by means of a manually operated three-way cock. As soon as the pipe systems and pumps were warmed up, the engines were able to run on this fuel without difficulty. A few minutes before shutting down, the system was switched back again to normal fuel, to avoid a possible blocking of the pumps, pipes and atomisers with bunker oil, which is very viscous when cold, so that its presence would have practically prevented the next starting operation.

Although these engines operated on such different fuels, there was no noticeable difference in the power developed. Both engines had an absolutely clear exhaust. At the rated power of 3000 hp, the exhaust temperature of the engine running on bunker oil was 290° C, or about 30 degrees higher than that of the engine using diesel fuel. The fuel consumption, measured daily, was naturally greater in the case of the engine using bunker oil, which showed an increase of 7-8 per cent. The greater portion of this increase, viz., 5-6 per cent, must be attributed to the lower calorific value of the bunker oil and the greater percentage of water which it contains, and only a small portion to the slower combustion of this oil. The lubricating oil consumption was about 2 kg per hour for either engine.

After each journey, at intervals of approximately 600 hours, the pistons were removed and all other equipment in contact with the hot boiler fuels was also inspected. Each time it was found that there was little difference between one engine and the other, as regards the cylinder heads, pistons and liners, etc., apart from a slight amount of wear in the upper piston ring grooves (0·05-0·10 mm in 6500 running hours) and greater rate of wear in the liners. After more than 9000 hours' running, the original atomisers were still in use. For the engine working on bunker oil C, the liner wear after 1000 running hours reached an average value of 0·14 mm, as compared with 0·10 mm for the engine running on diesel fuel. The wear of the cylinder liners was uniform over their entire height. Greater diameter differences than 0·2-0·3 mm were not observed on any component. The atomisers, the scavenge and exhaust ports, and the scavenge valves, were free from solid deposits and did not require cleaning. In this latter respect, the engine operating on bunker oil was even in a somewhat better condition, which may well have been due to its higher exhaust temperature.

Among the many other Fiat engines which operated with boiler fuels during the same period, mention should be made of the two-stroke cycle engines fitted to the motor tankers "Fede" and "Lavoro." These single-acting eight-cylinder engines had a bore of 680 mm and a rated power of 4000 shp at 125 rpm. From 1938 to 1940, these engines were run on bunker fuel only, with characteristics such as those given in Table III. In spite of the high sulphur content (about 3·6 per cent), the wear was not greater than in the previous cases and no signs of pitting were found.

While boiler fuels were thus being used successfully in single-acting engines for normal ship operation, further tests were carried out on a test-bed with a double-acting single-cylinder engine of 650 mm bore and 860 mm stroke. The lower combustion chamber, with the connecting rod passing through it, had to be provided with two atomisers and had a less favourable shape. New difficulties had to be overcome, such as, for instance, those due to incomplete combustion occurring with imperfect atomisation, as a result of which impurities with a high tar content were deposited, causing piston ring seizure and blocking of the scavenge and exhaust ports. After suitable modification of the injection system and the fuel atomisers, this test engine was run for 500 hours without interruption, on a bunker C type fuel, with the characteristics shown in Table IV. The power developed reached the remarkably high value of 1200 bhp at 175 rpm. In this case also, the cylinder heads, the stuffing boxes and the piston, as well as all other components, remained perfectly clean and showed no abnormal wear. Further good results were then also obtained with other double-acting engines of normal design in normal ship operation.

FURTHER DESIGN FEATURES

Rigidity of framework : Since 1923 the large marine diesel engines developed by Fiat have been built with a view to obtaining a high degree of rigidity by connecting the bedplate, columns and cylinders together so that they form a single block. This arrangement, which necessarily entails increased weight and cost, has since been adopted by other engine makers. All Fiat engines are now built in this manner, except the opposed-piston engines, in which the constructional requirements are such that only the middle sections of the cylinders are connected together. The cylinders are connected to the bedplate by means of special steel tie-bolts which reduce the stresses in the columns.

Cylinder head and upper part of piston: The cylinder head arrangement is shown in Fig. 5. In this latest design, the cooled cylinder cover comes well down into the cylinder and protects the uncooled portion of the liner against direct heat radiation.

The cylinder head, the upper part of the liner, and the piston crown are the parts which are exposed to the greatest thermal and mechanical stresses. With the much higher thermal stresses in the two-stroke cycle engine, cast iron was not found satisfactory, and since 1925 the cylinder head has been made of cast steel, the piston crown being of forged steel. The piston crown is heat-treated and hard chromium-plated to increase its oxidation resistance and reduce wear in the piston ring grooves. Besides being more suitable for welding and

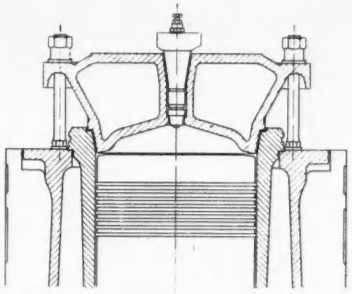
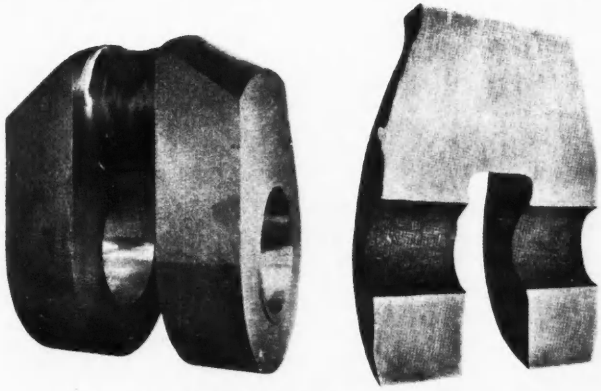


Fig. 5. **Latest cylinder cover arrangement.**

provisional alterations, steel offers greater security under abnormal conditions which frequently occur in practice, as, for instance, when the cooling water is not circulating for a short period of time.

Crankshaft: To simplify manufacturing, nearly all the large-size Fiat crankshafts made in recent years are of the semi-built type. The crankpin and its two adjacent webs are made from a C-shaped steel casting (see Figs. 6a and 6b). This design was evolved after extensive investigations, which also served to convince the shipping registers that the physical and mechanical properties of the material inside the casting are at least equal to those of the test plugs normally provided on the casting for materials testing.



Figs. 6a and b. **C-shaped steel castings of crankpin and webs.**

This type of crankshaft is now also being adopted by other makers of large-size engines. Practical experience has shown that the semi-built cast-steel crankshaft thus evolved makes it possible to obtain a more favourable shape for the flow of forces. With the alloy constituents used, the shaft properties have even shown considerable improvements as regards yield point, notch sensitivity and vibration resistance. Carefully designed transitions, surface hardening, and particularly the omission of the oil holes previously required for forced lubrication, have resulted in increased strength of the shaft with respect to torsional vibration, and the danger of fatigue fractures is practically eliminated.

THE DOUBLE-ACTING TWO-STROKE CYCLE ENGINE

This is, as far as possible, an accurate reproduction of the single-acting engine. The cylinder is provided with two liners. The upper liner, extending below the inlet and exhaust ports, is fitted from above, and the second, shorter, liner is fitted from below. The junction of the two liners is situated in a zone of moderate pressure, well cooled from the outside and sealed against gas and water pressure by copper and rubber rings.

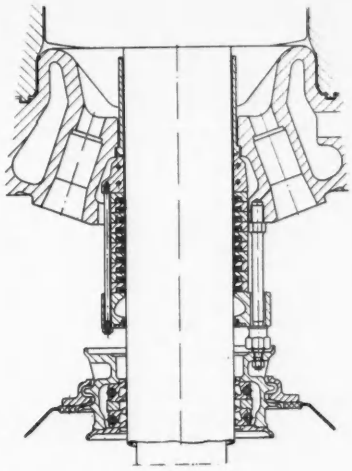


Fig. 7. **Stuffing box.**

The upper liner is removable in the same period of time as in the single-acting engine. The lower cylinder cover and liner are removed laterally. This requires more time, since the upper cylinder cover and piston also have to be removed for this operation. It is of interest to note that the piston, after loosening the fixing nut of the connecting rod in the crosshead, can be removed without difficulty in 45-50 minutes' time, calculated from the moment the engine is stopped.

The stuffing box, shown in Fig. 7, normally only requires checking and cleaning every 6000 hours. The sealing rings are situated as far as possible away from the hotter area, to maintain low lubricating oil temperatures and avoid oil burning.

The connecting rod not only sustains the mechanical loads but is also exposed to thermal stresses, since it passes through the lower combustion chamber and the lower cylinder space. It is also subjected to frictional stresses due to the action of the sealing rings in the stuffing box. Fig. 7 shows that the connecting rod is provided with a protecting tube which keeps the thermal stresses away from the connecting rod body. This steel tube is hard chromium plated for increased resistance to oxidation and wear. The cooling oil reaches the crosshead through articulated tubes, as in the single-acting engine, and passes through the space between the connecting rod and its protecting tube in order to reach the lower piston crown. Thus, it also maintains the protecting tube, which is in contact with the combustion gases, at a sufficiently low temperature. From the lower piston crown, the oil is supplied to the upper piston and then led back to the crosshead through a passage at the centre of the connecting rod.

In view of the fact that the surface of the lower piston is smaller, by an amount equal to the cross-section of the connecting rod, than the surface of the upper piston, and that the thermal efficiency is also lower,

(*Concluded on page* 274)

The "Vector-Meter"—A New Electrical Measuring Instrument

By F. KOPPELMANN. (From *Elektrotechnik und Maschinenbau*, Vol. 68, No. 2, January 15, 1951, pp. 27-30, and No. 9, May 1, 1951, pp. 225-29, 12 illustrations.)

A new instrument for the measurement of losses in dynamo and transformer core laminations is described and its principles and construction are dealt with in detail.

MOVING coil instruments coupled with dry rectifiers are extensively used for a.c. measurements. The principle underlying such measurements is illustrated in Figs. 1a and 2a. Owing to the high inertia of the coil, the instrument will register the mean value of the d.c. pulses produced by the rectifier.

Unfortunately, the accuracy and reliability of the moving coil instrument are appreciably lowered when it is used in this way, as the performance characteristics of barrier layer rectifiers are by no means ideal (e.g., resistance in the passing direction, back e.m.f., threshold voltage, temperature coefficient, creep). However, a synchronously operating mechanical contact will represent an almost ideal rectifier : the contact resistance can be made negligible, while the open-circuit resistance can be arbitrarily high. Contact chatter is somewhat more difficult to eliminate. Fig. 1b shows the principle of such a contact rectifier.

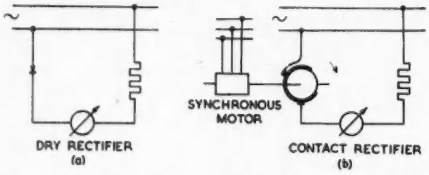


Fig. 1. **Principle of rotary contact rectifier compared with barrier-layer rectifier.**

To give an output similar to that of a rectifier, the brushes and the stator of the driving motor have to be adjusted so as to give a contact duration as indicated in Fig. 2a. On the other hand, this adjustability gives rise to fundamentally new possibilities of measurement.

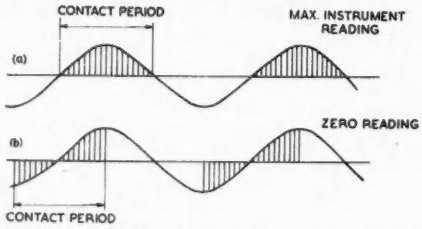


Fig. 2. **Contact periods of barrier-layer and contact rectifier.**

By rotating the stator, contact can, for example, be made at the maximum negative amplitude of the current (Fig. 2b), and broken at the positive peak value. This setting will be indicated by a null reading of the galvanometer. If, then, another current, differing in phase by an angle φ, is applied to the instrument, a null reading will again be obtained if the stator is rotated by the same angle φ. By providing the stator of the driving motor with a circular scale, the phase difference can, therefore, be directly read off the scale.

The instrument can thus measure not only current and voltage, but also the phase difference between them, justifying the name "vector-meter." While the principle of such instruments has been known for a long time, they have not been generally employed in a.c. measurements, owing largely to constructional deficiencies.

Fig. 3 shows the construction of a recently developed measuring contact. A long vertical spindle, running in

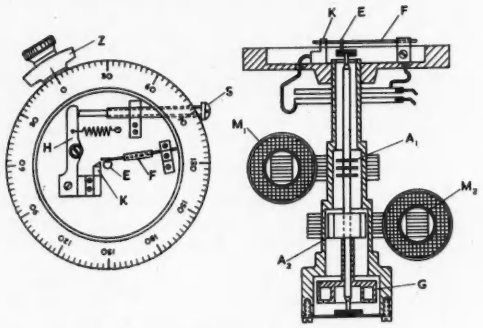


Fig. 3. **Construction of contact rectifier.**

silver bushings, carries two armatures A_1 and A_2, where A_1 is the rotor of the starting-motor (hysteresis motor), and A_2 the rotor of the synchronous driving motor. M_1 and M_2 are the stators. The spindle, running at 3000 rpm, carries an eccentric spigot E, which bears against the leaf-spring F, causing it to make and break contact with the fixed contact point K. The contact surfaces are made of gold. The contact K is adjustable by means of the screw S acting on the lever H, so that the duration of contact is variable between 20 and 340 degrees. The contact-housing and attached circular scale is rotatable through 360 deg. with respect to the fixed stator. By means of this rotation, the relation between the phases of the contact and the input voltage is altered. The zero-point indicator Z is also adjustable. Fixed at the bottom of the spindle is a flywheel G, which keeps the angular velocity of the spindle very nearly constant. By this means, an accuracy of 0·1 per cent in the phase-angle measurement is possible. The circular scale has a diameter of 115 mm, so that 1 degree of arc corresponds to about 1 mm, and 1/100 deg. can still be estimated. The spindle housing is hermetically sealed.

The complete instrument contains a number of shunt and series resistances, extending its range from 150mV to 300V, and from 50mA to 5A. A selector enables six successive measurements of different quantities to be taken.

By means of the selector switch, a built-in battery can also be brought into the circuit, enabling the contact duration to be measured and regulated. This allows far higher contact loads to be used than is the case, for instance, with vibrating-reed rectifiers, so that ordinary millivoltmeters and even control-panel and registering instruments can be used in conjunction with it. The upper load limit of the contact lies at about 100mA and 300V. The resistance of the closed-contact circuit, including contact-rings and leads, is about 0·03 ohm, and can thus be neglected even when using low-resistance galvanometers.

Vibrating-reed rectifiers, in which the contact phase is controlled either by a phase-shifter or by a rotary field of a single and an auxiliary phase, are subject to serious phase-errors when the frequency deviates from the nominal value. The present instrument, operating between frequencies of 15 to 80 cps, will have phase-angle errors not exceeding a few tenths of a degree.

When employing sensitive mirror-galvanometers, it is important that interference from the excitation coils of the motor be avoided. With suitable shielding, the

interference voltage induced in the leads has been reduced to the order of 10^{-6}V.

The field of application of mechanically rectifying measuring instruments is very wide. Not only currents and voltages down to very small values, but also phase-angles, active and reactive components, wave form, harmonics and fundamental frequencies, mean, peak and r.m.s. values, and magnetic field and induction strengths can be measured. From such basic measurements, new methods of investigation can, in turn, be developed. As an example of the application of the instrument, the measurement of iron losses in transformer and dynamo core laminations will be described.

The usual method of determining iron losses by means of the Epstein hysteresis tester necessitates the use of specimen strips of 30 mm width, 500 mm length and a total weight of 10 kg. If the weight is reduced, the deflection of the wattmeter becomes too small. However, single plates can differ considerably between themselves, yet cannot be singly tested on the Epstein apparatus. With the present instrument, a large number of plates can be tested separately, and sorted according to suitability.

The test consists in the magnetisation of the whole plate by means of a flat coil, and the active component of the coil current (coercive force) is measured. As the losses in each plate are of the order of a few watts, they cannot be measured by normal wattmeters.

Measurement of the active component

Fig. 4 shows the circuit employed. Terminal (1) is used in conjunction with the compensating resistance r and shunt r_n, for current measurement. Terminal (2) is used for the measurement of the voltage V. R_v is another compensating resistance. Let the voltage V differ in phase from the current i, so that it may be considered to consist of the active component V_a and the reactive component V_r. If contact is made in the instrument at time t_0 and broken at time t_2, it can be seen from the diagram that only the active component will be registered (assuming a contact period of 180 deg.). To set the phase-angle of the instrument, the selector-switch is turned into position (1) and the phase altered until the deflection is zero, i.e., contact is then made at time t_1 and broken at t_3. If, now, the phase is altered by 90 deg., it will be correctly set for the measurement of the active component alone, in position (2).

This procedure can only be adopted when current and voltage are purely sinusoidal in shape. The difficulties caused by higher harmonics can, however, be easily overcome if instead of the shunt r_n an inductance is employed, as will be seen below.

Fig. 5 shows the application of the inductance to what may be termed wave-form determination. Let the current in the primary contain an arbitrary number of (odd) harmonics ; if a contact period of 180 deg. is employed, the instrument in the secondary circuit will then have a deflection which depends on the phase-relation of the contact. By taking readings for different

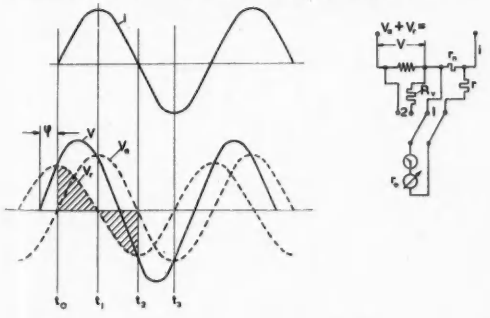


Fig. 4. **Measurement of active and reactive components.**

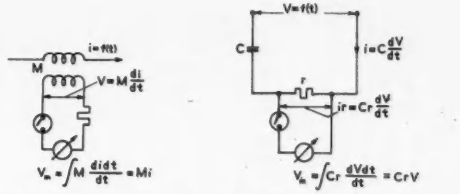


Fig. 5. **Wave form determination by means of inductance or capacitance.**

phase-angle positions of the contact, the primary current $i = f(t)$ curve can be obtained. To show this, let the voltage in the secondary coil be $V = Mdi/dt$. The mean value V_m of the indicated voltage is given, provided the total ohmic resistance Σr in the secondary circuit is large in comparison with the inductive reactance, as

$$V_m = \frac{r_0}{\Sigma r} \int_{\varphi}^{\varphi+180} M \frac{di}{dt} dt = M \frac{r_0}{\Sigma r} (i_{\varphi+180} - i_{\varphi}) = 2M \frac{r_0}{\Sigma r} i_{\varphi} \qquad (1)$$

where i_{φ} and $i_{\varphi+180}$ are the instantaneous values of the current at times φ and $\varphi + 180°$. The assumption that i has no d.c. component and no even harmonics is necessary here, as only then is $i_{\varphi} = -i_{\varphi+180}$. (This condition is always satisfied for magnetising currents, if the core has no d.c. excitation and no ramanence).

In iron loss testing, not the complete wave-form of the current, but only a certain instantaneous value of the current is of interest, as will be shown below.

Measurement of the hysteresis loop

By means of the search-coil W_2, placed around the plate under test (Fig. 6), the induction B in the iron can be measured as follows : let the voltage in the coil be $V = n_2 q dB/dt$, then the time-integral of the voltage indicated by the instrument will be, similarly to eq. (1)

$$V_m = 2 \frac{r_0}{\Sigma r} n_2 q B_{\varphi} \qquad .. \qquad (2)$$

where n_2 = number of turns in the search-coil, q = iron cross-section, $B_{\varphi} = B_{\varphi+180}$, the instantaneous value of the induction B at times φ and $\varphi + 180°$.

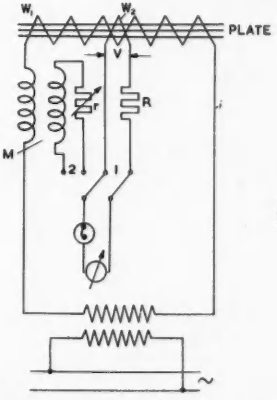


Fig. 6. **Basic circuit for hysteresis measurement.**

Thus, with the selector-switch in position (1), B is determined as a function of time, while in position (2) the magnetising current i or (by conversion through the number of turns in the coil W_1, and the length of magnetic path l) the field-strength H is indicated. If these values are plotted against each other, the hysteresis curve of the specimen will be obtained

(Fig. 7). For peak values of the induction which are not too high (B_{max} = 13,000 gauss for normal silicon steels), the width of the hysteresis loop, i.e., twice the coercive force, is a fair measure of the area of the loop, and thus of the hysteresis loss. If, then, in Fig. 6, the switch is in position (1) and the phase of the meter contact is set for $B = 0$, i.e., for zero deflection of the galvanometer, then in position (2) the coercive force H_o can be read off, giving a direct indication of the iron loss.

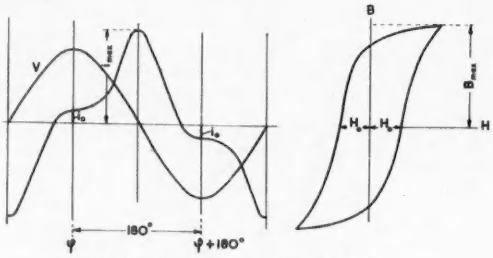


Fig. 7. **Measurement of coercive force.**

Fig. 7 also gives the curves for V and i. When the contact phase is set at φ and $\varphi + 180°$, then according to eq. (1), i_o will be indicated, and hence $H_0 = i_0 \frac{n_1}{l}$ can be calculated. It must be noted, however, that the magnetic path length l is uniquely defined only for a uniform winding and a closed magnetic circuit. In the apparatus to be described, the plates are magnetised by an open coil, and the magnetic path is incomplete. It follows that an empirical calibration of the instrument is necessary.

Description of Apparatus

Fig. 8 shows the circuit diagram of the measuring apparatus. It corresponds to the diagram of Fig. 6. The measurement is carried out as follows : First the rheostat R_1 is adjusted until the voltmeter G, which is calibrated in kg, shows the weight of the plate. (For a given length of plate, the voltage necessary to produce a given value of induction is proportional to the width and thickness of the plate, i.e., is proportional to its weight.) The value of the resistance R_2 is such that the mean value of the induction B over the length of the plate is about 10,000 gauss when the voltmeter G indicates the weight of the plate. (The mean value of the induction is measured during calibration by means of a uniformly wound coil, e.g., the search-coil W_2, and is therefore the exact value, i.e., is not affected by the wave-form of the voltage).

After setting the value of the induction, the phase-angle of the rotary contact is adjusted, with the switch in position (1), so as to give a zero reading on the galvanometer O. The value of the iron loss can then be directly read off the meter V_{10}, with the switch in position (2).

As already mentioned, the magnetic circuit is incomplete. A measurement was carried out with the vector-meter to determine the values of the induction at different points along the length of the plate. For a mean value of 10,000 gauss over the whole area, it was found that the induction at the centre was about 12,000 gauss. As the iron losses in normal materials used for plates are the same function of the induction from 0 to about 12,000 gauss, the non-uniformity of the induction is taken care of in the calibration.

A moving iron instrument was used for the voltmeter G, and the required voltage (in terms of weight) could be set to an accuracy of about 1 per cent. At induction values of 10 to 12,000 gauss, the reactive component of the magnetising current (i_{max} in Fig. 7) is greater by a factor of 5 to 10 than i_o, which is proportional to the loss figure. As a consequence, the indicated loss is very sensitive to the correct phase-setting of the rotary contact. To reduce this sensitivity, which is a source of error, an additional voltage ΔV is introduced into the measuring circuit by means of a variometer. This voltage is in phase with the voltage in W_2, which controls the phase-setting of the contact. With correct setting, ΔV therefore does not affect the reading of the meter V_{10}, while, on the other hand, its magnitude is so chosen that it approximately compensates the wattless current component, so that even if the phase is incorrectly set, the reading on V_{10} will still be approximately true.

V_{10}, a moving coil instrument, is given a constant negative bias through a small transformer, which excites a nickel-iron core N to saturation. The secondary winding on the core will yield voltage pulses, the mean value δV of which, as rectified by the rotary contact and suitably directed, provides the required bias.

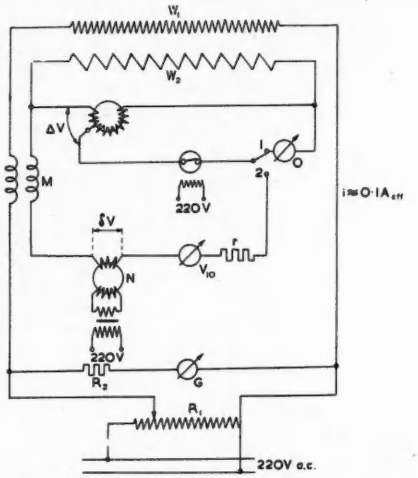


Fig. 8. **Wiring of iron loss measuring apparatus.**

With these refinements, the apparatus will measure iron losses with an accuracy of 1 per cent. It was calibrated against a standard hysteresis tester. Inaccuracies of the Epstein method are, of course, included in the calibration, but since this method is standardised in many countries, this is no disadvantage. The apparatus can easily be constructed for several measuring ranges. The width of the plates does not enter into the measurements (except for the weight), but a separate calibration is necessary for different lengths.

The apparatus measures losses for a magnetisation along the length of the plate. To determine losses in the cross-wise direction, the appropriate magnetising coils must, of course, be constructed.

General Remarks

In the application described above, the vector-meter is not employed in its normal form, as essentially only the rotary contact rectifier is used. Nevertheless, the discussion illustrates the scope of the instrument, as, for example, the measurement of active and reactive components, which can usually only be determined indirectly, e.g., by the use of wattmeters or oscillographs. Similarly, the determination of wave-form by the use of inductances or capacitors (Fig. 5) is of general interest. The instrument also provides the basis for the construction of, e.g., magnetic susceptibility or initial permeability meters.

The Measurement of Chip Deformation during Turning

By W. LEYENSETTER. (From *VDI-Zeitschrift*, Vol. 93, No. 13, May 1, 1951, pp. 375-378, 10 illustrations.)

Measurements of chip deformation reveal the characteristic interaction between tip metal and work material. The compression of the chip depends on cutting speed, rake angle, tip metal, and general cutting conditions. It differs widely for high-speed steel and carbide-tips and is largely affected by changes in the cutting edge. For very high cutting speeds, deformation conditions with negative rake angles approach those of positive rakes.

THE dimensions of a continuously flowing chip differ from the dimensions that could be expected theoretically for given cutting conditions: the chip is compressed longitudinally and expands in width and breadth. This three-dimensional deformation may be expressed by the three ratios: λ_1 = distance travelled by cutting edge, divided by actual chip length, λ_2 = actual, divided by calculated, breadth of chip, and λ_3 = actual, divided by calculated, width of chip. The values of the ratios thus defined are always greater than unity. The actual chip length can most easily be determined if one or two narrow axial grooves are cut into the work piece, e.g., a shaft, and steel sheets inserted in these grooves. The length is then clearly defined and can be measured out by means of a thread. The chip deformation, and especially the longitudinal compression, has repeatedly been used as a characteristic value of cutting conditions and of the theory of chip formation, and it has been found by tests that turning tools of identical shape, but different tip metals, lead to completely different amounts of the longitudinal compression λ_1. It is therefore worth while investigating also the influence of the work metal on the chip compression.

In the following tests, the shape of the cutting tools was that of a rough-turning tool according to German standards, with side and end cutting edge angles of 30 deg., an end relief angle of $\alpha = 5$ deg., and a rounded tip of 0·5 mm radius. Carbide-tipped and high-speed steel cutting tools of various rake angles, + 25 deg., +14 deg., — 10 deg., were used. The cutting edge was ground and lapped accurately to the above values in a tool grinder with suitably adjustable dividing head. The tip was rounded by means of an oil-stone and the radius checked by template. The work metal was plain carbon steel according to German standards, and its tensile strength was calculated from the measured Rockwell hardness. One axial groove of 0·16 in. width and about 0·63 in. depth was milled into each shaft before turning, and a steel sheet ground to the required thickness was pressed into the groove. The turning tests were performed on a lathe with infinitely variable drive, the cutting speed being increased from 65 fpm in steps of 32·5 fpm up to a maximum speed of 520 fpm for carbide-tipped tools, or a speed just below the braking speed for high-speed steel tools. Further tests were then taken with similarly decreasing cutting speeds, since it could be shown that the chip compression varies according to whether the cutting speed increases or decreases. Before each test, the surface of the shaft was prepared by turning with a high-speed steel at low speeds and small feeds. The chip compression during this preparatory turning is very small, and we may therefore assume that it does not noticeably influence the chip deformation during the tests. The colouring of the chips was also observed as a rough comparative guide to the local temperature obtained during the tests.

Fig. 1 shows the chip compression λ_1 during turning of 0·15 per cent C-steel with a given, unchanged shape of the cutting tool. The chip length could easily be measured and the average length of 5 chips was regarded as a characteristic value. Only where results showed appreciable deviations, an average of 10 tests was taken. Above 100 fpm cutting speed, the chip compression caused by the high-speed steel exceeds that caused by the carbide-tipped tool. During tests with the high-speed steel, the cutting speed was increased in steps up to 510 fpm and then again reduced in steps. The great differences in chip compression for increasing and for decreasing speeds (see Fig. 1) seems due to build-up at the cutting edge of the tool and is so pronounced only because of the high maximum speed attained. Similar tests with a maximum cutting speed of only 360 fpm do not show any noticeable difference between increasing and decreasing speeds. In fact, a cutting tool causes less chip compression after running-in than immediately after re-grinding as shown by Fig. 2 where the compression appears to tend to a limiting lower value with increasing running time. The influence of the rake angle on chip compression also

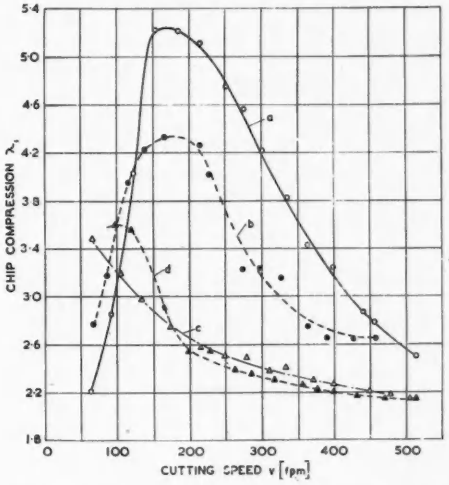


Fig. 1. **Chip compression λ_1 as a function of increasing and decreasing cutting speeds v on 0·15 per cent C-steel.** Rake angle: + 14 deg., cutting depth: 0·12 in., feed: 0·0165 in./rev.

a = high-speed steel, increasing cutting speed;
b = high-speed steel, decreasing cutting speed;
c = carbide-tipped tool, increasing cutting speed;
d = carbide-tipped tool, decreasing cutting speed.

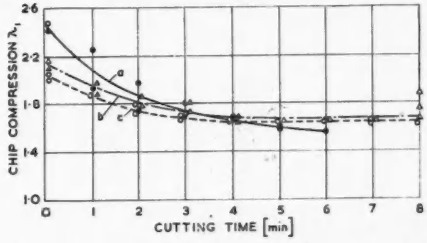


Fig. 2. **Chip compression λ_1 as a function of the cutting time of high-speed tools with various rake angles.**

Work material: 0·35 per cent C-steel in tempered condition, cutting depth: 0·063 in., cutting speed: 175 fpm, feed: 0·012 in./rev.

a = + 14 deg. rake angle; b = + 20 deg. rake angle; c = + 25 deg. rake angle.

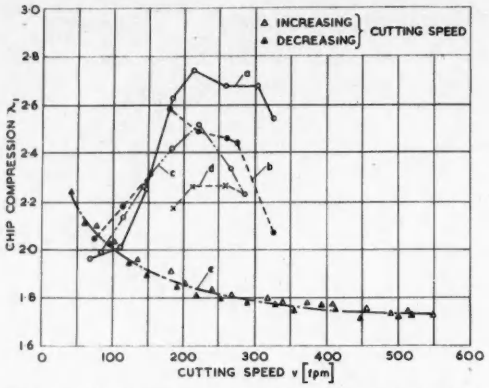


Fig. 3. **Chip compression λ_1 as a function of the cutting speed v on 32-ton steel, with continuously used cutting tools and cutting tools re-ground for each increase in speed.**
Rake angle: + 25 deg., cutting depth: 0·12 in., feed: 0·0165 in./rev.
a = high-speed steel re-ground for each increase in speed.
b, c = high-speed steel, continuously used, increasing speed;
d = high-speed steel, continuously used, decreasing speed;
e = carbide-tipped tool, continuously used, increasing and decreasing speed.

diminishes with increasing cutting time. The effect of the build-up is again shown in Fig. 3: The chip compression observed at speeds above 200 fpm is higher if the high-speed steel cutting tool is re-ground

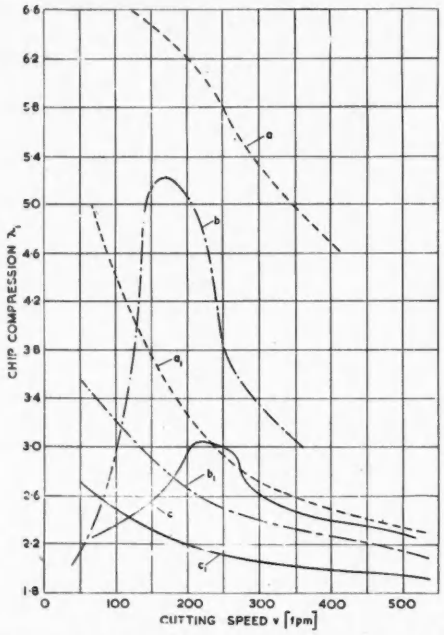


Fig. 4. **Chip compression λ_1 as a function of the cutting speed v on 0·15 per cent C-steel, with high-speed steel and carbide-tipped tools of various positive and negative rake angles.**
Cutting depth: 0·12 in., feed: 0·0165 in./rev.
a = high-speed steel, — 10 deg. rake;
a_1 = carbide-tipped tool, — 10 deg. rake;
b = high-speed steel, + 14 deg. rake;
b_1 = carbide-tipped tool, + 14 deg. rake;
c = high-speed steel, + 25 deg. rake;
c_1 = carbide-tipped tool, + 25 deg. rake.

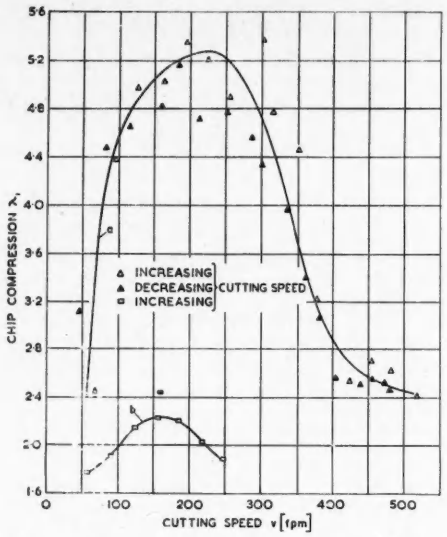


Fig. 5. **Chip compression λ_1 as a function of the cutting speed v on 22-ton and 38-ton steels with high-speed steel tool.**
Rake angle: +25 deg., cutting depth: 0·12 in., feed: 0·0165 in./rev.
a = 22-ton steel; b = 38-ton steel.

before each speed increase than if it is left untouched. The differences shown for increasing and decreasing speeds are noticeable even with very small chip cross-sections, e.g., feeds of 0·008 in. per revolution, but can hardly be detected if a carbide-tipped tool is used (Figs. 1 and 3).

The smaller the rake angle, the higher is the chip compression (Fig. 4). The highest compression ratios are obtained for negative rake angles. The differences, however, decrease with increasing cutting speeds, and it can be assumed that with very high cutting speeds, the rake angle hardly influences the chip deformation. These conclusions are valid for high-speed steel as well as carbide-tipped tools, and the characteristic curves of Fig. 4, derived from tests on 0·15 per cent C-steel, are repeated, albeit with slightly less pronounced differences, for tests on 32-ton steel. No simple connection could be found between the static strength of the work material and its chip deformation. The amount of chip compression can probably be related to the tendency of the chip to weld to the tool tip, and this tendency is smaller with carbide-tipped than with high-speed steel tools. With the latter steels, the chip compression first increases with increasing, though low, cutting speeds, an effect probably caused by increasing friction without build-up at the tool tip. As the speed, and therefore the local temperature of the chip, reaches higher values, build-up due to welding becomes possible. Finally, at still higher speeds, the very high local temperature reduces the strength of the work material so that the welds break off more easily and chip compression again decreases. It is also possible that a plastic layer at the tool tip then reduces the overall chip compression. In tests with carbide-tipped tools, the chip compression decreases continuously as the speed is increased from very small values upwards. Since the amount of chip compression is seen to change rapidly even with small changes of the cutting edge, it may well serve as a criterion of the state of the tool edge during cutting.

Fig. 5 finally compares the cutting qualities of two structural steels (22 and 38 tons U.T.S.). The harder

(*Concluded on page* 254)

How Titanium behaves at Temperatures up to 900° F

By W. L. WILLIAMS. (From *The Iron Age*, Vol. 167, No. 24, June 14, 1951, pp. 81-84, 6 illustrations.)

Light weight and erosion resistance make titanium a natural choice for steam turbine blades. Although the best properties will be found in titanium base alloys, this study shows how commercially pure titanium can be expected to behave at temperatures up to 900° F.

TITANIUM and its alloys have useful properties at temperatures between those suitable for aluminium alloys and ferritic steels. Of particular interest are the properties at temperatures common to modern steam power turbines. Its light weight makes it attractive for rotating parts, and the high erosion resistance to wet steam makes titanium suitable for turbine blades. Yet, in spite of these attractions, very few data have been published regarding its elevated temperature properties.

TABLE I. MATERIALS TESTED.

Identifying symbol Melted in graphite by : Hot forged, then : Diam. of finished bar	IA Induction Annealed 1300° F 1"	AA Arc Annealed 1300° F $\frac{3}{8}$"	AC Arc Cold-rolled 21% $\frac{3}{8}$"
Composition, per cent			
Carbon	0·58	0·16—0·46	
Sulphur	0·010	0·009	
Manganese	0·04	0·05—0·09	
Silicon	< 0·002	< 0·002	
Copper	0·001	0·002—0·004	
Iron	0·13	0·11—0·13	
Magnesium	< 0·01	< 0·01	
Nitrogen	0·022	0·001—0·003	
Chlorine	Nil	Nil	
Tungsten	Nil	Nil	
Oxygen	Results not yet available.		

The tests described here were made on two commercial ingots. One of these was a 77-lb ingot produced by induction-melting in graphite. The other was produced as a 35-lb ingot arc-melted in graphite. Pertinent details are given in Table I. The broad range of carbon content reflected the inhomogeneity often found with arc-melted materials. Both ingots were sectioned for two finishing treatments : Hot forge—anneal, and hot forge—cold work. However, cold working of the induction-melted material was not successful ; internal bursts formed at all working temperatures up to 1400° F.

The tensile properties up to 900° F are shown in Fig. 1. Each plotted point represents an average of two or more determinations. All materials show a levelling-off of the strength properties within the range of 500 to 800° F. This is a characteristic of titanium. It can probably be ascribed to the taking into solution with increasing temperature of some constituent, possibly carbon. The induction-melted and arc-melted materials, IA and AA, had similar strength properties despite their difference in carbon content. This observation fell in line with the conclusion of Gee[1]) that carbon in this range has little effect on the tensile strength. Nitrogen is known to have an appreciable effect on the ultimate strength at room temperature. However, the difference in nitrogen content of materials IA and AA was not great enough to be felt.

A comparison of the annealed and cold-rolled arc-melted titanium, AA and AC, was of interest. The yield ratio, as well as the yield strength and tensile strength, was increased by cold working. The superior properties of the cold-rolled product were maintained up to 900° F in the short-time tensile tests. One would not expect this superiority to be maintained so noticeably in long-time tests, especially at higher temperatures at which there is a fairly rapid removal of the effects of cold work[2]).

Published values for the elastic modulus in tension have been erratic. This has been attributed to either variations in the material or laxities in experimental testing[3].) The data shown in Fig. 2 lead one to believe that material variations are the predominant cause. Each of the curves shown was determined from exceptionally careful measurements on a single specimen, so that variations between specimens would be eliminated. The procedure was to measure the modulus first at room temperature and then at successively higher temperatures. Despite all these precautions, some differences and scatter were observed.

Some modulus measurements have been made on titanium materials other than those shown in Fig. 2.

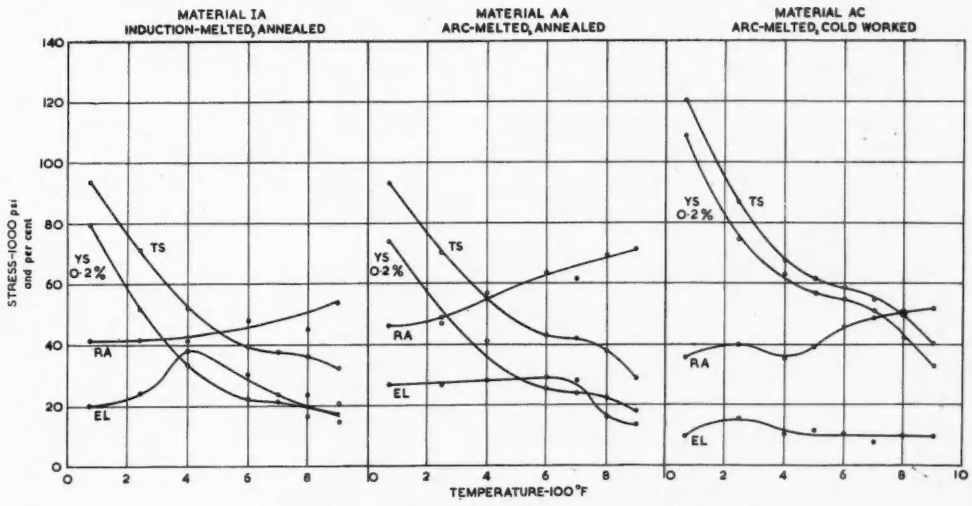


Fig. 1. **Tensile properties of titanium as a function of temperature.**

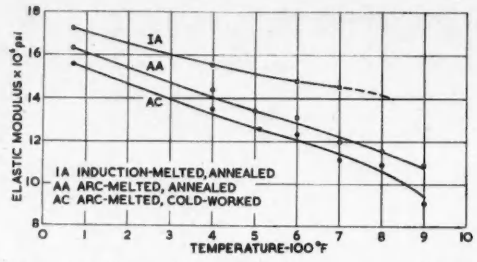


Fig. 2. **Elastic modulus of titanium as a function of temperature.**

Rather marked and reproducible discontinuities were noted occasionally in the modulus-temperature curves, especially in the range of 500 to 900° F. In some cases a detectable change occurred in the room temperature modulus after heating in this range. One is led to suspect that subtle structural changes take place at the intermediate temperatures.

Stress-rupture and creep data typical of titanium are given in Table II. Time-extension measurements were taken during the stress-rupture tests. These enabled the calculation of minimum creep rates for the longer stress-rupture tests, and consequent extension of the creep graphs to regions of higher creep rate.

TABLE II. CREEP AND STRESS-RUPTURE PROPERTIES.

Type of material	Temp. °F	Stress, psi, for fracture in 100 hr	500 hr	1000 hr	Stress, psi, for min. creep rate, 1% in 10000 hr	100000 hr
Induction-melted, annealed, IA	600	38000	37000	36000	....	20000
	700	33000	32000	29000	25000	....
	800	24000	19500	17500	13000	9000
Arc-melted, annealed, AA	700	37000	36000	35000	....	....
	800	25000	16000	13500	....	....
Arc-melted, cold worked, AC	600	64000	62000	61000	57000	43000
	700	54000	45000	42000	29000	18000
	800	33000	26000	23500	13500	8500
	900	17000	12000	10000	....	....

Up to 600 or 700° F the stress-rupture strength was very nearly equal to the short-time tensile strength at the corresponding temperature. For example, titanium AA broke on loading to 38,000 psi at 700° F, but the same material endured 510 hours before rupture when loaded to 36,000 psi at 700° F.

When plotting the data from Table II, the most important observation was the tendency of the curves to converge at low rates of creep. The 800° F data showed this particularly well. Since the creep tests were run for a minimum of 2,000 hr, it was apparent that the long sojourn at temperature minimized the high strength advantage of the cold-worked product.

TABLE III. TENSILE PROPERTIES SHOWING EFFECTS OF PROLONGED HEATING OF COLD-WORKED TITANIUM, MATERIAL AC, DURING CREEP TESTS.

Exposure temp., °F	Exposure time hr	Tersile strength psi	Yield at 0·2 % psi	Elong. in 2 in. %	Red of area %
Room	....	120400	109100	10	36
600	2136	118300	110400	10	26
700	2028	106300	91400	12	26
800	2016	90600	70800	16	26

The data listed in Table III were obtained from room temperature tensile tests of the exposed creep specimens. These data illustrated even more vividly the very definite effects of prolonged heating of the cold-worked titanium, AC.

In pulling the specimens after the creep tests, it was found that the variations between duplicate specimens were considerably less than would have been the case for the same material prior to creep exposure. A similar behaviour was noted for other lots of titanium. Therefore, it was fairly certain that some subtle form of homogenization or structural change occurred with time at temperatures below 900° F.

The strength properties of titanium and of the alloys now being produced do not match those of ferritic steels at the temperatures associated with modern steam power turbines. This is not so much of a disadvantage for rotating parts where the principal stresses result from centrifugal force. For example, the centrifugal force on a steel turbine blade would be about 1·7 times as great as the force on a titanium blade of the same design under similar operating conditions.

It was only natural, then, that interest was focussed on titanium for turbine applications. However, for steam turbine service the blade material must be resistant to erosion in high velocity steam. Dry superheated steam is no problem, but wet steam conditions are especially damaging.

A useful apparatus was devised at the Engineering Experiment Station to compare the steam erosion resistance of various materials. The equipment consisted of an arrangement for directing high-pressure steam through a nozzle so as to impinge on the sharp apex of a concave-sided simulated blade section. Several specimens could be run simultaneously, so that comparisons of the materials were possible without precise control of the moisture content of the steam.

Several tests have been made with titanium and titanium base alloys. These specimens were exposed for 45 days to steam taken from a saturated steam line averaging 550 psi gauge pressure and 480° F temperature. Weight loss data for the specimens were as follows: Type 403 steel (abt. 12 per cent chromium), 0·094 gram; titanium, 0·018 gram.

It is not difficult to predict some of the advantages to be gained by alloying. Quite naturally one can expect better tensile properties at all temperatures, but it will be the stress-rupture and creep properties, and especially the latter, which should benefit the most. This will be brought about by increased structural stability and resistance to tempering at elevated temperatures.

The tests of the unalloyed metal point to another possibility not yet fully taken advantage of. It seems apparent that mild cold-working offers a simple way to improve the properties of some alloys even beyond that gained by heat-treatment or alloying *per se*. For example, certain alloys are now used in the annealed conditions. Some of these could be strengthened by mild working without too serious a reduction in ductility. The strength so gained would remain effective over long periods of time except at the highest of useful temperatures.

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(3) TITANIUM METALS CORP. OF AMERICA, "Handbook on Titanium Metal."

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(*Concluded from page* 252)

steel shows much the smaller chip compression and is cut much more easily. These final tests were taken as part of an investigation into the saw-cutting of the steels, when it was discovered that the saws were blunted much more rapidly by the 22-ton steel, which easily forms a build-up at the tool edge, than by the 38-ton steel. The differences between tests with increasing and decreasing cutting speeds are very small here.

Chemical Effects in Internal Combustion Engines

By J. J. BROEZE. (From *Polytechnisch Tijdschrift*, Vol. 6, No. 25-26, June 26, 1951, pp. 437a-441a, 14 illustrations.)

Previously, combustion processes were mainly investigated from the points of view of mechanics and thermodynamics. This article will go back to the starting point and emphasise the essentially chemical features.

WHEN an engine is stripped and the piston examined, it is found that "carbon," or possibly even "hard carbon," is present in the groove of the top piston ring. A statement of this kind would obviously seem too vague for a chemist. His examination would show that the substance consists mainly of a large percentage of highly oxidised binding medium, pertaining to the humic acid class mixed with somewhat highly dehydrogenated condensation products, known as "soot." This explanation by the chemist is extremely valuable, particularly when he adds that this particular oxidation product can only be formed as a result of an oxidising effect at approximately 250° C on an oil-to-metal boundary layer, and not in a completely liquid or gaseous phase, so that this must be the result of the oxidation of the thin oil film which adheres to the piston material.

Soot formation can only occur within a certain range of temperatures and when there is a temporary lack of oxygen. Under these conditions, soot is obtained as a result of the cracking of the superheated hydrocarbon molecules and the precipitation of the dehydrogenerated skeletons. Once formed, this product is so resistant to oxidation that, if it is cooled down to below 1200° C, its life will be greater than the duration of one engine cycle. Thus, it can be concluded that this product must have entered the groove from above and is a result of the combustion process. By similar analyses, it is possible to determine gradually the origin of each type of deposit in the engine as well as the origin of the constituents of fouled oil and of the colour and smell of the exhaust gases. With this knowledge, we should be in a position to find suitable methods of improvement.

A brief consideration of the reactions between hydrocarbons and oxygen will be of interest. There are many aspects worth considering:—Temperature differences; oxidation of oil at 70-125° C; deposits in piston-ring grooves, formed at about 200-250° C; pre-flame reactions at 250-500° C; flames up to 2500° C. There are reactions in the liquid and the gaseous phase; self-ignition and flame propagation; blue and yellow flames; weak and rich mixtures; wet and dry mixtures. All these features are of importance for engine life and performance, and regarding most of these very little is known.

The most generally known type of oxidation is that of the oil in the crankcase in the liquid phase, occurring as a result of its high temperature and its absorption of oxygen from the air. Oil is practically always saturated with oxygen, excepting when the oxidation rate is extremely high. Even then, the extremely thin oil films which flow down the walls of the running engine provide sufficient accessibility.

All these reactions are chain reactions. Aromatic constituents, particularly those occurring in the fractions of the lubricating oil, consist of naphthalene nuclei with alkyl tails. They absorb oxygen extremely rapidly and form resins which are soluble in oil. With further oxidation, the resins develop into finely distributed colloidal substances which become a flaky oxidation sludge. This substance contains very little oxygen and is soluble in light aromatics (benzene). Large quantities can be deposited by centrifugal action and surface effects, for instance, when finely distributed water gets into the oil, by condensation, and result in a blockage of the lubricating system. Generally speaking, the aromatic constituents are nowadays eliminated from the oil, particularly in the case of high-grade engine oils.

The main constituent then frequently has a paraffinic character. At engine temperatures the affinity of paraffin for oxygen is remarkable and at about 120° C it oxidizes rapidly, producing fatty acids. The reaction products contain many volatile light acids as well as formic and acetic acid. Peroxides are formed as intermediate products and these are very important, since the oxygen present in them is extremely active and is easily transferred to the subsequent phases. To prevent corrosion, it is important to ensure that the volatile fatty acids are eliminated, and this is one of the main reasons for providing sufficient ventilation. In engine crankcases the ventilation is generally adequate; in turbine lubricating systems, additional ventilation is frequently necessary. The air will not affect the oil, since it is already saturated.

At temperatures above 150° C which sometimes occur, the reaction can suddenly become dangerous and cause damage to certain bearing materials containing lead and cadmium.

These combustion reactions are very involved mechanisms and depend on many factors which can determine or alter their course. Fortunately, this fact can be used to delay the reaction or to break one of the links of the chain, for instance, by adding anti-oxidising substances which annihilate combustion products.

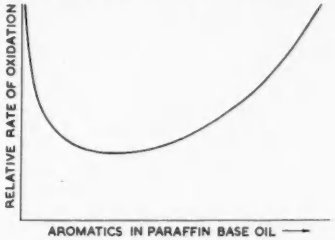


Fig. 1. **Aromatics and oxidation resistance.**

Regarding reactions in the liquid phase, it is remarkable that a slight percentage of aromatics (Fig. 1) has an anti-oxidising effect on the transformation of paraffins into fatty acids, and this also applies to certain sulphur compounds which are frequently found in natural oils. This indicates, therefore, that oils must not be over-refined until all the non-paraffins are eliminated. Furthermore, the stability against oxidation in the liquid phase should not be increased beyond certain limits, considering that another feature appears which must be reckoned with, viz., the decrease in the dispersing capacity in connection with oxidation products. This will be discussed later on.

An entirely different type of oxidation takes place in the vapour phase, when oil vapours react with oxygen at somewhat higher temperatures in the region of 200-300° C. This reaction can take place between lubricating oil and air in the hotter clearance spaces of the piston and between the piston and the cylinder when blow-by occurs. The oxidation can also take place between fuel and air in the first stages of self-ignition. When an engine is cold and ignition is first initiated, streams of oxidation products can be formed. The products of these reactions are aldehydes and

peroxides which condense as high-molecular products, known as lacquers. These products have a brownish or black appearance and are soluble in alcohol in consequence of their OH group. The oxygen content is higher than for the first group and reaches 20-25 per cent. These products can be found on piston walls and frequently in the lower piston ring grooves, where they sometimes cause seizure of the lower piston rings. In the case of inadequate combustion or late ignition in a cold engine, heavy deposits of lacquer may occur over the entire cylinder wall, with the result that restarting the engine may be impossible (Fig. 2). The products are completely insoluble in oil.

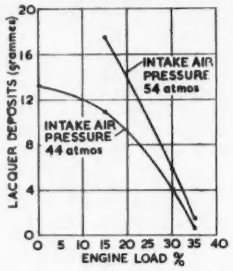


Fig. 2. **Influence of engine load and intake air pressure on lacquer deposition.**

The particular oxidation products formed at high piston temperatures on oil-to-metal boundary layers have already been mentioned. They constitute the third type of deposit due to engine oils, and their presence limits the temperature in the top piston-ring groove and on the inner surface of the piston crown to values which may be attained without risk of seizure of the top piston ring or severe carbon formation on the piston. The use of anti-oxidising substances makes it possible to operate at considerably higher temperatures. In this connection it is necessary to emphasise the importance of a more accurate knowledge of the working temperatures of pistons. The Royal Dutch Shell laboratories have developed a method for the continuous measurement of piston temperatures, using thermocouples fitted at all important positions of the piston. The thermocouples are connected to contact points which are closed when the piston is in the bottom dead centre position. The circuit includes a potentiometer which can be adjusted to obtain zero readings (Fig. 3), an inductively coupled amplifier, and a monitoring oscillograph, which indicates any voltage deviations. After zero adjustment of the potentiometer, readings are taken from a millivoltmeter. The accuracy is approximately $\pm 1{\cdot}5^{\circ}$ C. With this circuit it is possible to determine directly the effects of load variations, intake and exhaust system adjustments, etc.

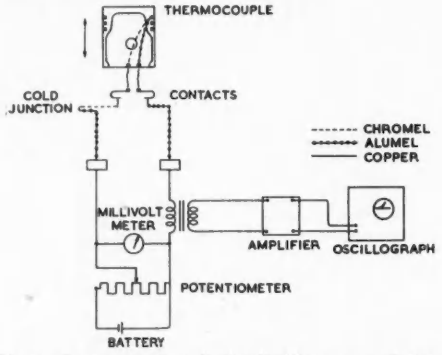


Fig. 3. **Arrangement and circuit diagram used for the measurement of piston temperature.**

In a particular instance, this equipment was used to determine the rotation of the top piston ring. It was observed that each time the piston ring gap passed a given measuring position, a rise in temperature was recorded. The test was made on an aircraft engine running at 2400 rpm and it was found that the top piston ring rotated at a speed of about one turn per minute.

In another case, the problem was to determine whether a certain diesel engine could safely be converted into a gas engine with a higher rating. By means of the equipment described, after an extremely small number of running hours, it was possible to show that the piston temperature of the converted engine would be even lower than when it was operating as a diesel engine, and that safe running conditions were obtainable without any alterations to the piston.

The actual conditions conducive to engine fouling and oil ageing are very involved, since they are related not only to the degree of oxidation but also to the effects of combustion products, of which soot and lacquer have already been mentioned. This is mainly a question of equilibrium :—First, equilibrium between the rate of formation and the rate of dissipation (Fig. 4) (as a result of burning and of losses in the oil consumed), and secondly, equilibrium between the quantities of these oxidation products and the quantities which can be contained in the oil in the form of solutions or suspensions (Figs. 5 and 6).

Some types of oil oxidise more readily than others but nevertheless keep the engine just as clean. It is only in the last 10 or 12 years that the practical significance of this fact has been realised. Until then it was known that engines remained more or less clean under different conditions and with different kinds of lubricating oils, but this fact was more or less implicitly accepted until it was shown, in the United States, that very considerable improvements could be obtained by adding saponaceous substances to the oil, with the result that much cleaner piston surfaces were obtained, particularly in high-speed engines where maintenance was a critical problem and piston seizure a relatively frequent occurrence. It was found that these additives mainly acted on the flaking tendency and the adhesion to the walls of the oxidation products, when these became insoluble. As a colloidal chemist would say, they " peptise " these products. This is the result of a surface action, a section of physical chemistry which is in many respects of importance to the engine maker, since it deals with boundary lubrication, emulsions, corrosion and wear. These additives, known as detergents, are being extensively employed. The total quantity of oxidation products in the lubricant is not appreciably lowered by these additives, but the products are removed from the dangerous positions. As the flaking of the finely distributed particles is prevented, the oil rapidly becomes black. The use of these additives has resulted in an increased use and popularity as well as an increased load capacity of the high-speed diesel engine.

Attention has recently been concentrated on the fact that very high percentages of additives are necessary to obtain the required results, although theoretically a few hundredths of one per cent ought to be sufficient. It has been shown by Dr. van der Minne that the peptising effect is counteracted by oxidation resins which are formed in the oil. These resins also have some peptising effect and are responsible for the remarkable results obtained with strongly oxidisable oils. The question of these counteracting constituents has been further investigated and has led to new conceptions regarding anhydrous colloidal substances.

A complete section of the very important subject of engine chemistry, i.e., that dealing with sulphur and its oxides, will be omitted from this article, since it

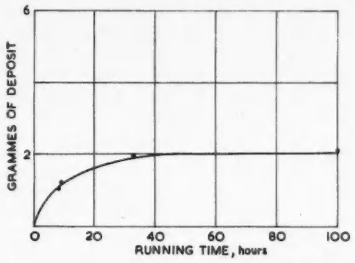


Fig. 4. **Deposition of carbon in the combustion chamber.**

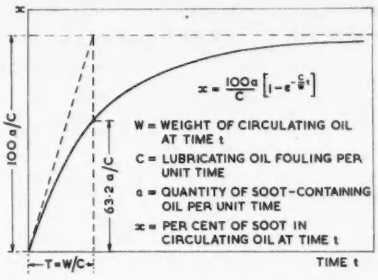

x
100 a/C
63·2 a/C
T=W/C
TIME t
x = 100a/C [1 − e^(−C/W t)]
W = WEIGHT OF CIRCULATING OIL AT TIME t
C = LUBRICATING OIL FOULING PER UNIT TIME
a = QUANTITY OF SOOT-CONTAINING OIL PER UNIT TIME
x = PER CENT OF SOOT IN CIRCULATING OIL AT TIME t

Fig. 5. **Theoretical fouling of oil.**

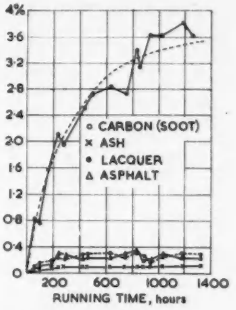


Fig. 6. **Equilibrium in lubricating oil fouling.**

has been extensively treated elsewhere[1]. The chemistry of oxides at high temperatures, which is of great importance for sparking plugs under certain conditions, will also be omitted. In place of these subjects, various points concerning flames will now be discussed.

In a previous article[2] the author dealt with the complex radical reactions occurring in flame ignition. The following paragraphs will refer to another characteristic of the flame, viz., radiation.

It is, of course, well known that hydrocarbon flames can be blue or yellow. These two types have very different radiation characteristics, which affect the heat losses of the flame. It is true that radiation is of greater importance to the industrial fuel user than to the engine technician.

In engines, the heat losses through convection are of preponderant importance, owing to the high density and violent motion of the burning gases, and the small flame dimensions. The heat loss through radiation is small. For a given flame condition, this radiation varies with the flame dimension e according to the law $1 - e^{-kl}$, where k is an emission coefficient. In combustion turbines, with lower gas densities and combustion chambers of somewhat larger size, radiation can be of more direct importance. Radiation, however, is more than a heat loss. The chemical processes of blue and yellow combustion are clearly different, and, although they lead to the same final result, their intermediate products are completely different, since they are the constituents causing engine fouling and the undesirable constituents in the exhaust gas. The blue flame is the result of an accompanying breakdown of the hydrocarbon molecules, which, while forming radicals, are converted into aldehydes and low-molecular acids; free carbon never occurs, excepting atomic carbon during an extremely short period of time, so that its structure and dimensions are smaller than those of particles which can be visually observed.

The blue flame characteristics are as follows:— luminescence due only to high-temperature gas radiation; blue colour coming from CH and C_2 radicals (with perhaps some CO radiation as well); line spectrum attributable to impurities of inorganic origin, such as sodium compounds; while cooling through contact with cold walls, formation of CO, and aldehydes, condensing or oxidising as acids, but no soot formation.

This reaction requires an unusually homogeneous, but not excessively rich, mixture. The required conditions can be fully achieved in a spark-ignition engine, operating on dry fuels, as well as in vapour burners of the type used in combustion turbines.

By using a special atomiser burner, in which the atomising and mixing were developed to a very high degree, it has been possible to show that all completely volatile types of hydrocarbons can be burnt with a blue flame, at fuel/air ratios reaching, or even exceeding, the theoretically correct value. When mixture conditions are less favourable, the process is still completed to a considerable extent, but where unusually rich particles occur, the hydrocarbons will crack as a result of the intense heat. Carbon skeletons, formed in the short time before the particles can reach the oxygen in their vicinity, will then condense into small groups which can be observed optically as particles emitting a black radiation. This evidence shows that the phenomenon is initiated at a very definite critical ratio of the components.

Thus, an intensive radiation of a continuous character is generated, together with the possibility of soot formation in the combustion gases or on cold walls. In the combustion gases, this phenomenon can be caused by a deficiency in oxygen, but it is generally produced by the cooling down of the carbon particles to a temperature below 1200° C, as a result of which the carbon/oxygen reaction is rapidly delayed. This explains the soot in the exhaust gases of diesel engines and combustion turbines, where the enormous excess of air stops the reaction as far as carbon particles are concerned. The soot forming on the walls of the combustion chamber is also due to similar circumstances. These can even occur in the spark ignition engine, when the mixture is sufficiently moist, owing to the effect of rich groups of particles present in each droplet. Considerable difficulty was experienced in the operation of an engine with quartz windows until the mixture was carefully dried. When this was done, it was possible to operate even with rich petrol mixtures.

It is worth noting that, as might be expected, the diesel engine usually has a certain amount of soot in its lubricating oil, but the amount of carbon formed by the lubricating oil in the combustion chamber is relatively small, because the excess air is sufficient to burn it. In the petrol engine, there is little or no soot in the used oil, but, owing to the fact that the mixture is at approximately the theoretically correct value, the lubricating oil in the chamber will not burn until a certain equilibrium density is reached and the carbon deposit begins to glow.

CONCLUSIONS

As already mentioned, the general state of an engine as regards fouling depends, at any given instant, on whether the conditions of equilibrium which were described above are reached or exceeded. It is necessary to know the laws governing these equilibrium conditions, since the ideal state will be that in which conditions of equilibrium will permit a build-up of deposits without dangerous effects; it will then be

(*Concluded on page 264*)

(1) Sulphur in Diesel Fuels, by J. J. Broeze and A. Wilson, *Proc. Inst. Mech. E., Automobile Division*, 1948-1949, Part II, pp. 128-145.

(2) *Polytechnisch Tijdschrift*, No. 24, 1951.

GERMANY

Practical Rules for the Adjustment of Automatic Control Processes

By W. OPPELT. (From *Chemie-Ingenieur-Technik*, Vol. 1951, No. 8, pp. 190-193, 2 illustrations.)

AN automatic controller device cannot merely be mounted, in the same way as a measuring instrument, on an existing installation, in the hope that satisfactory regulation will result. The difference between the controller and a measuring instrument is that the controller acts on the process which is to be controlled and must, therefore, be adjusted to give favourable operating conditions.

To achieve these conditions, the plant engineer must know (1) the characteristics of the plant which are involved in the control process, (2) the possibilities of adjustment of the controller device which is to be adapted to the process considered, and (3) the general criteria and requirements for obtaining optimum adjustment.

This article will deal only with " continuous " systems, in which the positioning device can assume any intermediate position, contrasting with " on-off " type regulators which operate only in their two end positions. The discussion will be confined to " single-loop " systems, in which the controller and the controlled installation are connected together so as to form a single closed circuit.

BASIC TYPES OF CONTROLLERS AND CONTROLLED UNITS

Generally, the controllers used are of the proportional-integrating type. In these systems, the controller acts on the positioning device with two regulating effects:—(1) a proportional effect, which varies in the same way as the variations of the controlled quantity, and (2) an integral effect, which is determined by the integral of the variations over a certain period.

The controller response to a sudden unit-amplitude deviation of the controlled quantity is shown in graph " R " of Fig. 1. The linear portion of the controller response curve is characterised by the proportionality factor V_R, which indicates the corresponding variation of the positioning member when the controlled quantity is varied by one unit. The integral portion of the curve is characterised by the time T_n required for the readjustment. Usually, the integral effect is obtained by incorporating an elastic element in the restoring device. The time T_n of the readjustment is, in this case, equivalent to the time constant of the elastic restoring device.

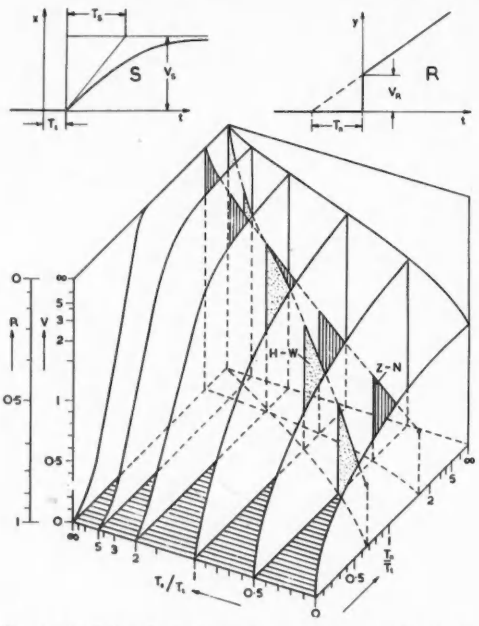


Fig. 1. **Stability limits and optimum values of adjustment according to Ziegler-Nichols (*Z-N*) and Hazebroek-Van der Waerden (*H-W*).**

The controlled systems met with in chemical plants generally include a dead time-lag T_t. This is defined as the time which elapses until the readjustment of the positioning device first becomes noticeable as a variation of the controlled quantity. After a further period of time, as a result of the variation, the controlled system reaches a new steady-state condition. This position is determined by the factor V_S which represents the variation of the controlled quantity relative to the command of the positioning device. The time required for the new steady-state condition to be reached is determined by the time constant T_S of the controlled path. The variation of the controlled system, following a sudden unital displacement of the positioning device, is shown in graph " S " of Fig. 1.

STABILITY LIMITS

The controller parameters V_R and T_n cannot be arbitrarily chosen. An unfavourable adjustment will make the control process become unstable by resulting in oscillations of increasing amplitude. It is important, therefore, to know the limits for V_R and T_n which should not be exceeded. These limits depend also on the characteristics of the controlled system, and particularly on the time ratio T_S/T_t and the magnification factor V_S.

The limits of the adjustment range can be calculated and plotted as shown in the lower diagram of Fig. 1. This diagram indicates the allowable values for the magnification factor V of the entire control circuit, which are obtained from the relation: $V = V_R V_S$. A given control path, characterised by its value for the ratio T_S/T_t, will cut out of this three-dimensional figure a vertical surface connecting those values of $V = V_R V_S$ and T_n/T_t which are allowable for adjustments in the case being considered. Fig. 1 shows six of these surfaces, for $T_S/T_t = 0$, 0·5, 1, 2, 5 and ∞. Intermediate values are easily estimated.

It is of interest to consider the outer limits of this figure, which are known as the " stability limits." The *left side-surface*, for which $T_S/T_t \to \infty$, represents a controlled path with a dead time-lag T_t equal to zero. In this case, the magnification factor V could assume any arbitrarily large value, without giving rise to oscillations of increasing amplitude, provided that T_n/T_t remains greater than unity. The *rear surface*, denoted by $T_n/T_t = \infty$, is valid for the proportional controller. For this type of controller, the integral contribution is zero, this being frequently obtained in practice by means of a " rigid " restoring element. Fig. 1 shows that the proportional controller always enables adjustments to be made for the maximum possible values of V along a given path. The *right side-surface*, for which $T_S/T_t = 0$, is valid for a controlled path with dead time-lag only. Controlled paths of this type occur, for instance, in systems controlling the mixing of two streams of fluid, the dead time-lag being due to the finite velocity of the flow between the adjustment position and the measuring position. In this case, the allowable values of V are the smaller values, with V never exceeding unity.

OPTIMUM ADJUSTMENTS

For practical operating conditions, the controller should be adjusted so that it will remain well away from the stability limits, in order that the oscillations of the controlling process may be sufficiently damped. The position of " optimum adjustment " is, of course, a matter of opinion and depends on the views of the engineer in charge of the plant. For example, one user will consider a controlling process with a fairly large number of small oscillations to be suitable, whereas another will prefer a control process with a few large-amplitude oscillations and a rapid decay rate.

On the basis of extensive series of practical measurements, certain rules were established by ZIEGLER and NICHOLS for the optimum adjustment of control processes. They avoid using data for the controller and the controlled unit which have to be determined by individual tests, since such data can only be obtained, in practice, with a considerable amount of labour and require interruptions in normal plant operation. They propose, instead, the following procedure:—The controller is first connected as a purely porportional controller. Its magnification factor V is then increased until the control process begins to develop undamped oscillation characteristics. This position is a " critical " condition at the adjustment limit. Then, after measuring the period T_{crit} of this steady-state oscillation and noting the position corresponding to V_R on the controller device, according to Ziegler and Nichols, the optimum adjustment is obtained when

$$V_R \simeq 0{\cdot}5\ V_{Rcrit} \text{ and } T_n \simeq 0{\cdot}83\ T_{crit} \quad .. \quad (1)$$

Furthermore, an easily applied rule is needed for determining optimum adjustment values by calculation. The suggested procedure is to use, for this purpose, the surface representing the variation of the control process with respect to time and relatively to the steady-state line. Its minimum area is then determined by a method of least squares, that is, each amplitude taken at regular intervals along the base-line is squared. This gives a positively defined curve. The area bounded by this latter curve is then determined so that it will have a minimum value. Optimum values of adjustment using this squared-amplitude method have been determined by HAZEBROEK and VAN DER WAERDEN for a series of control processes. Their results are also indicated in Fig. 1.

The optimum values determined by Ziegler and Nichols and those given by Hazebroek and Van der Waerden show only slight differences as regards V. The values for T_n/T_t are somewhat larger, for small values of T_S/T_t, when calculated from the data of Ziegler and Nichols. However, for large values of T_S/T_t, which are generally obtained in practice, the two methods show good agreement.

TABLE I. PRACTICAL FORMULAE FOR THE CALCULATION OF CONTROL PROCESSES.

CONTROLLER	CONTROLLED UNIT	STABILITY LIMIT V_{CRIT} or c_{CRIT}	STABILITY LIMIT T_{CRIT} =	REMARKS
		$V_{CRIT} \approx \frac{\pi}{2}\frac{T_S}{T_t} + 1$	$2T_t$ if $T_t \gg T_S$ $4T_t$ if $T_t \ll T_S$	
		$c_{CRIT} = \frac{\pi}{2}\frac{1}{T_t}$	$4T_t$	APERIODIC if $c = 0{\cdot}37/T_t$
		$c_{CRIT} \approx \frac{1}{T_t}$	$\approx 2\pi\sqrt{T_0\,T_t}$	$c = c_R V_S$ or $c = c_S V_R$
		$T_0/T_t \gg 1$		$c_S = 1/T_0$
		$c_{CRIT} \approx \frac{\pi}{2}\left(\frac{1}{T_t} - \frac{1}{T_n}\right)$	$4T_t$ if $T_n \to \infty$ $5{\cdot}5T_t$ if $T_n = 2T_t$ ∞ if $T_n = T_t$	
		$V_{CRIT} \approx \frac{\pi}{2}\frac{T_S}{T_t} + 1$ if $T_n/T_t > 2$	$2T_t$ if $T_t \gg T_S$ $4T_t$ if $T_t \ll T_S$ and $T_n \to \infty$	$\frac{1}{V_{CRIT}} = \frac{T_t}{T_n} - 1$ for $T_S/T_t \to \infty$
		$V_{CRIT} \approx 4\pi D\frac{T_S}{T_0}$	T_0	for $T_0 \ll T_S$
		$c_{CRIT} \approx 4\pi\frac{D}{T_0}$	T_0	

SIMPLIFIED CRITERIA

For practical work, the general results given in the three-dimensional diagrams are somewhat cumbersome. The practical engineer works mainly by rule of thumb, even if this gives only approximate views of the relationships involved. In Table I, a number of simplified criteria and rules of thumb are indicated for the most important types of control circuits. These criteria were obtained from the graphical representations of the stability limits, using the rules applying in practical mathematics. By means of these rules and the equations (1), the values for optimum adjustment can be determined for each case. The transient function, indicating the behaviour of the controller and controlled unit after a sudden initial disturbance, is also included in this Table and serves to distinguish the various cases.

Table I also shows cases for which the transient function increases continuously in amplitude after a disturbance, without reaching a new steady-state condition. Cases of this kind occur when using an integral controller or a controlled unit without compensation. In such cases, no magnification factor can be given, since the system does not tend towards a steady state. The system is characterised by the velocity c of the variation (the rate of change of amplitude) and also, particularly for uncompensated paths, by the starting time T_a, this being defined as the time required for a unit change of the controlled quantity. In integral controllers, for the same reason, the rate of adjustment is not used and the circuit is characterised by the time T_v required by the positioning device to cover its full range at maximum velocity. The stability limits for uncompensated control processes are indicated in Fig. 2.

Finally, Table I also includes cases in which there is no dead time-lag and in which the controller itself constitutes an oscillating system. These cases include, for instance, various pressure controllers and voltage controllers, in which the measuring device has an appreciable mass, as well as speed governors of the centrifugal tachometer type. The quantities D and T_0 denote, respectively, the damping coefficient and the period of the natural or free vibration with zero damping.

THE CONTROL FACTOR

For the assessment of control processes, it is, in many cases, important to know to what fraction a deviation from the required value is reduced by means of the controller, after an external disturbance. The quantity used in this connection is known as the control factor R. This factor is related to the magnification factor $V = V_R V_S$ of the control circuit by the expression

$$R = \frac{\text{deviation with controller}}{\text{deviation without controller}} = \frac{1}{1 + V} \quad .. \quad (2)$$

Usual values for R are between 0·2 and 0·02, for corresponding values of V between approximately 4 and 50. In Fig. 1 the ordinates are given with corresponding values of R and V.

The control factor can, of course, only be determined

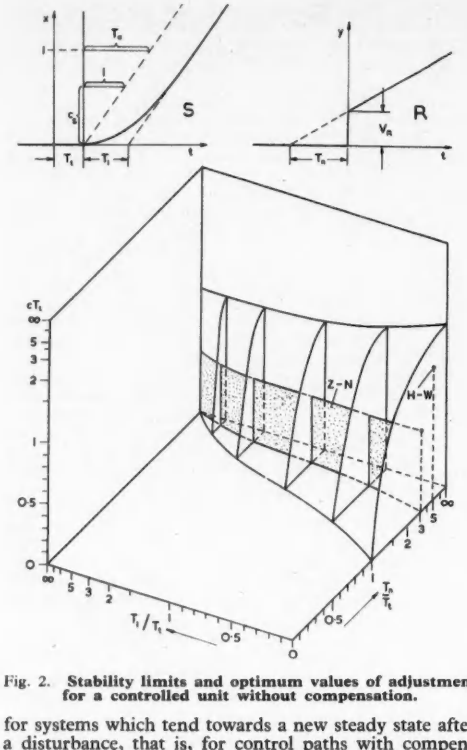


Fig. 2. **Stability limits and optimum values of adjustment for a controlled unit without compensation.**

for systems which tend towards a new steady state after a disturbance, that is, for control paths with compensation and proportional controllers. For controllers of the proportional-integral type, the control factor gives an indication of the magnitude of the initial deviation after a disturbance, the deviation occurring mainly under the influence of the proportional part of the controller.

In many applications, it is found that T_S greatly exceeds T_t. For such cases, the approximate formula $V \leq \pi\,[(T_S/T_t) + 1]/2$ of Table I can be replaced by $V \leq \pi\,T_S/(2T_t)$, and this, in conjunction with eq. (2), gives the simple relation

$$R_{crit} \simeq 0{\cdot}64\ T_t/T_S \qquad .. \qquad .. \quad (3)$$

This approximate formula indicates the fraction to which a deviation can be reduced by a proportional controller without coming into the unstable region of increasing oscillations. It shows, furthermore, that this maximum reduction is determined by the time ratio T_S/T_t of the controlled path, and that it cannot be improved by alterations in the proportional controller. Since, in actual practice, it is necessary to remain as far as possible away from the stability limit, a favourable adjustment of the controller will be obtained by means of the following approximate relation

$$R_{opt} \simeq 1{\cdot}3\ T_t/T_S \qquad .. \qquad .. \quad (3a)$$

ILLUSTRATIVE EXAMPLE

The use of the practical approximation formulae (3) and (3a) as well as the formulae of Table I will be illustrated in the following numerical example.

A steam-heated drying chamber is to be provided with temperature control. The steady-state conditions in the drying chamber are found to be 80° C with the steam valve fully opened and 20° C with the valve closed. A constant temperature of 60° C is required. Owing to steam extraction for other purposes, the steam pressure fluctuates occasionally, and the temperature drops to 52° C. The temperature decrease is to be prevented by a controller which will open the steam valve more fully when necessary, in order that the temperature shall not drop below 58° C. The time constant of the drying chamber has been found to be $T_S = 210$ sec., and the dead time-lag is $T_t = 30$ sec.

1. *Can stable conditions be expected with a proportional controller?* The control factor is $R = (60\text{-}58)/(60\text{-}52) = 0{\cdot}25$. The time ratio is $T_S/T_t = 210/30 = 7{\cdot}0$. According to eq. (3), it would be possible, in this case, to obtain a control factor $R_{crit} = 0{\cdot}64/7 = 0{\cdot}09$ without producing oscillations of increasing amplitude. Furthermore, according to eq. (3a), the optimum adjustment also gives a control factor lower than that required, viz. $R_{opt} = 1{\cdot}3/7 = 0{\cdot}18$. A proportional controller is, therefore, sufficient to fulfil this first requirement. Moreover, the use of the more accurate formulae of Table I gives $V_{crit} = \pi\,(7 + 1)/2 \simeq 12$ and hence $R_{crit} = 1/(1 + 12) = 0{\cdot}077$. Accordingly, we have $R_{opt} = 0{\cdot}143$.

2. *What is the value of the magnification factor V_R of the controller if a control factor $R = 0{\cdot}25$ is required?* The corresponding value of V for the entire control circuit is $V = (1/R) - 1 = (1/0{\cdot}25) - 1 = 3{\cdot}0$. The magnification factor of the controlled path is $V_S = 60°$ C. The temperature change, expressed as a percentage of the valve adjustment, is: $100 \times \Delta T/\Delta a = 0{\cdot}6°$ C/per cent. Since $V = V_S\,V_R$, we have $V_R = V/V_S = 3/0{\cdot}6 = 5$ per cent valve adjustment per °C.

3. *What is the period of oscillation T_{crit} of the control process if V_R is increased until permanent oscillations occur?* From Table I, we have: $T_{crit} = 4\ T_t = 4 \times 30 = 120$ sec.

4. *If a proportional-integral controller were used, to what value would it be possible to reduce the time of readjustment T_n?* From Fig. 1, we see that $R = 0{\cdot}25$ (or $V = 3$) and $T_S/T_t = 7{\cdot}0$ correspond to a value $T_n/T_t \simeq 0{\cdot}9$. Therefore, T_n would have to be greater than $0{\cdot}9\ T_t = 27$ sec in any case, to avoid unstable controller operation. A favourable value for T_n, according to Fig. 1, could be expected if $T_{n\,opt} \simeq 3{\cdot}3\ T_t = 3{\cdot}3 \times 30 = 100$ sec.

5. *What is the value of the velocity of adjustment c which should not be exceeded, for reasons of stability, when using an integral controller?* According to Table I, the value of c for this case is: $c = c_R\,V_S \leq 1/T_t$. Therefore, $c_R = 1/(0{\cdot}6 \times 30) = 0{\cdot}055$ per cent valve displacement per ° C per sec. For example, if an adjustment $x_h = 5°$ C is required from the controller in order to obtain the full controlling velocity, then this corresponds to an adjustment time $T_{v\,crit} = 100/(0{\cdot}055 \times 5) = 370$ sec. A proportional control process is obtained with $T_v = 2 \times 370 = 740$ sec.

BASIC MATHEMATICAL RELATIONS

Let x = controlled quantity, y = travel of positioning member.

Controller equations:

proportional controller $y = V_R x$

integral controller $y = c_R \int x\,dt$

proportional-integral controller $y = V_R x + c_R \int x\,dt$

$$\text{or } y = V_R \left(x + \frac{1}{T_n} \int x\,dt \right).$$

Controlled path equations:

compensated, without dead time-lag $T_S x' + x = V_S\,y$

not compensated, without dead time-lag $T_a x' = y$.

The simplest way of taking account of the influence of

(*Concluded on page 264*)

Electrical Determination of Unbalance Forces in Rotors

By F. BURLANDO. (From *Rivista di Ingegneria*, Vol. 1, No. 4, April, 1951, pp. 373-379, 17 illustrations.)

WHEN a rotor is rotating at an angular velocity ω about its axis, it is subjected, in the most general case, to the centrifugal components $\overline{P}_1 = P_1 e^{j\varphi_1}$ and $\overline{P}_2 = P_2 e^{j\varphi_2}$, situated in two planes perpendicular to the axis of rotation. Under such conditions, the unbalanced rotor will transmit dynamic loads and deflections to its bearings. The forces and deflections will vary sinusoidally in any fixed direction taken as line of reference at right-angles to the rotor axis.

The vibrations of a bearing in a radial direction are governed by the equations

$$x = P \cos(\omega t - \alpha) \Big/ \sqrt{(k - m\omega^2)^2 + c^2\omega^2}$$

$$\alpha = \tan^{-1}\left\{ c\omega/(k - m\omega^2) \right\}$$

where P = peak value of the impressed force, x = vibration amplitude, α = phase angle of the vibration, k = stiffness of bearing support, m = sum of the rotor masses in relation to the bearing plus a certain proportion of the mass of the latter, and c = damping coefficient of bearing support. At resonance, $\omega = \omega_r$, and $k - m\omega_r^2 = 0$, so that

$$\alpha = \pi/2 \text{ and } x = x_{max} = P/(c\omega_r).$$

The force P is the resultant of the excitations $\overline{P}_1$ and $\overline{P}_2$ referred to the position of the bearing. To eliminate the vibration of the bearings, it is necessary to determine in any two planes perpendicular to the axis of rotation, and situated at fixed positions along the rotor, the forces $\overline{P}_1$ and $\overline{P}_2$ both as regards magnitude and phase, in order to be able to balance the machine by means of additional masses.

In the method which will be described, the angles φ_1, φ_2 and the magnitudes P_1 and P_2 of the impressed forces will be obtained by oscillograph indications.

DESCRIPTION OF METHOD

The velocity of rotation is maintained within speed ranges for which $\alpha = 0$ deg. or $\alpha = 180$ deg. so as to avoid resonant conditions. During each period of vibration, the positions of $\varphi_1 = \omega(t_1 - t_2)$ and $\varphi_2 = \omega(t_1' - t_2)$ are determined. The times t_1 and t_1' are the instants at which the vibration components assume a certain value (for instance, zero), and the time t_2 corresponds to the instant at which the rotor passes through an arbitrarily chosen reference position.

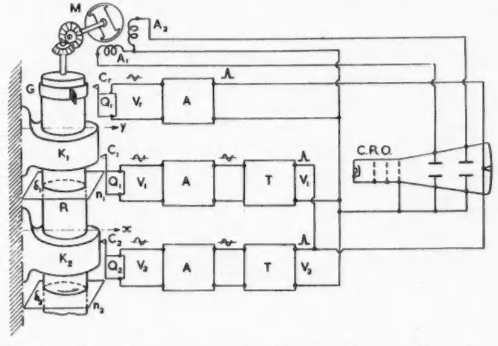


Fig. 1a. **General arrangement of measuring equipment for rotor balancing.**

R = rotor being tested; $K_1 K_2$ = bearings rigidly anchored; x, y = fixed directions through the bearings; $n_{1,2}$ = planes chosen for the compensation of the centrifugal components; C_1, C_2 = pick-ups in contact with bearings; C_r = trip contact on rotor shaft G; M = two-pole magnet with two-phase winding; Q_1, Q_2, Q_r = crystal transducers; A = amplifier stages; T = circuits converting periodic voltages into pulse voltages; *C.R.O.* = cathode ray oscillograph; V_1, V_2 = vibrations of bearings transmitted to crystal transducers; V_r = periodic pulse due to the action of pad G against contact C_r.

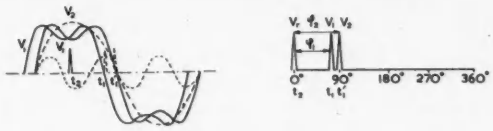


Fig. 1b. **Wave-forms of vibrations V_1, V_2 and V_r, the time base being calibrated in degrees.**

The instants t_1, t_1' and t_2 are indicated by electrical pulses according to the general arrangement shown in Fig. 1. The pulses are injected into the oscillograph circuit and superimposed on the time trace, which is calibrated in degrees. In this manner, it is possible to determine the angular positions φ_1 and φ_2 of the peak values of the dynamic loads, relatively to the reference position.

The time trace is generated by an electrical vibration with the same frequency as the bearing vibration. Generally, straight-line traces have been used, but these traces are limited by the tube diameter and are not linearly graduated, that is, their divisions for equal angular intervals are not of uniform length, so that the measurement accuracy may not be sufficient. The equipment which is being described uses either a circular or a spiral trace, and enables the graduations to be spread out considerably without increasing the diameter of the cathode-ray tube.

Circular trace: The electrical oscillations generating the circular trace are two phase-voltages with an angular frequency ω which are applied to the vertical pair of deflecting plates of the cathode-ray tube. These voltages can be obtained either (a) directly from the two-pole magnet M of Fig. 1, which is synchronously

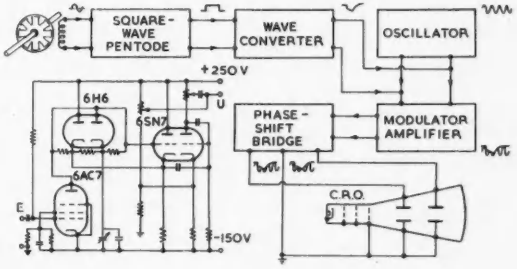


Fig. 2a. **Circuit diagram for spiral trace.**

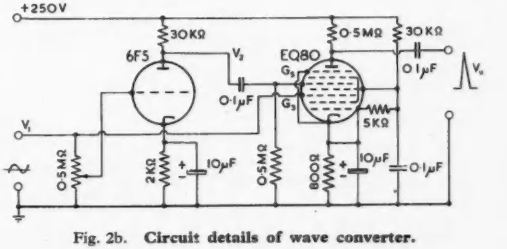


Fig. 2b. **Circuit details of wave converter.**

driven by the rotor being tested and rotates between the windings A_1 and A_2, the magnetic axes of which are in quadrature, or (b) indirectly, by means of a voltage generator of variable frequency, i.e., an electronic oscillator, which is connected to an RC phase-shift bridge circuit with equal reactances on opposite sides.

Spiral trace: The trace can be extended still further by acting on the electron beam so that it will describe a number of non-superimposed turns forming a spiral curve on the oscillograph screen. The spiral trace is obtained as the resultant of two motions:—

1. A circular motion, generated by two phase-voltages with a radian frequency $n\omega$ (for a spiral with n turns), the voltages having a relative phase angle of 90 degrees. These voltages are produced either in the manner already described, that is, with an electronic oscillator, or by means of an n-pole two-phase magnet synchronously driven by the rotor, or, in a third arrangement, by a two-pole magnet driven by the rotor through a gear system with a step-up ratio of $1:n$.
2. A motion towards the centre of the oscillograph screen, obtained by amplitude modulation of the above voltages by means of a third voltage with a frequency ω and with a special waveform generated by the electronic circuit of Fig. 2.

The emission of pulses, which appear on the oscillograph screen when the periodic vibrations in the bearings pass through zero amplitude, is obtained by means of the circuit of Fig. 3. This circuit comprises a 6F5 phase inverter triode and a 9-electrode valve EQ80. The mechanical vibrations are converted into electrical oscillations by means of transducers of the piezo-electric, magnetodynamic or electrodynamic type. The transducers are mounted at fixed positions on the periphery of the bearings. The pulses thus generated are applied to the grids G_3 and G_5 of the EQ80 valve.

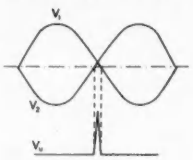


Fig. 3. **T-circuit of Fig. 1, conversion of periodic oscillation into pulses.**

The electrical pulses acting on the grid G_3 come directly from the transducer and are nearly in antiphase with the pulses applied to grid G_5, since these pass through the phase-inverter triode 6F5.

The nine-electrode valve becomes conductive only during the instants when the vibrations applied to the grids G_3 and G_5 are simultaneously positive. It produces, then, impulses of considerable amplitude, corresponding to the passing through zero of the oscillations.

The transducers most commonly used for converting mechanical vibrations into electrical oscillations are of the piezo-electric type, with a crystal receiving the vibrations through a steel needle which is in contact with the bearing. In the magnetodynamic type, the vibrations act directly on the support of the moving coils, and hardly affect the magnetic mass owing to the elasticity of the sponge-rubber mountings of the coils. In the electrodynamic transducer used for rotor testing, the vibrations are picked up by a pivoted arm which periodically passes over a position at which it closes a magnetic circuit. The circuit is, then, excited by a primary coil, and induces a voltage pulse in a secondary coil. For increased sensitivity, the motion of the follower arm is mechanically amplified by a system of gears driving an oscillating sector.

The reference position or zero-degree position of the rotor is indicated during each revolution by a contact which operates whenever the zero-degree point on the rotor passes through a given direction. In the arrangement of Fig. 1, the zero-degree pulses are obtained by means of a piezo-electric transducer Q_r, connected to a flexible arm C_r, which is periodically struck by a rubber pad G fixed on the rotor shaft.

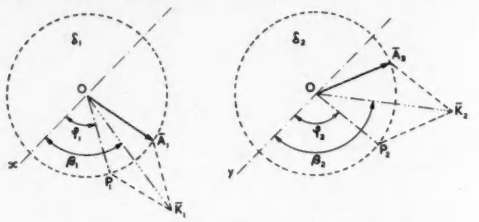


Fig. 4. **Diagrams for the determination of the absolute values of OR_1 and OR_2 in the planes n_1 and n_2 of Fig. 1.**

The tests are carried out as follows:—In the planes of $\overline{P}_1$ and $\overline{P}_2$, the rotor is provided with additional masses which will create centrifugal forces $\overline{A}_1$ and $\overline{A}_2$ of known magnitude and direction. Oscillograph recordings serve to determine the values of φ_1, φ_2 and β_1, β_2, which are obtained before and after this modification, and which refer, respectively, to the forces $\overline{P}_1$, $\overline{P}_2$ and the resultants $\overline{K}_1$, $\overline{K}_2$ of these forces with the known forces $\overline{A}_1$ and $\overline{A}_2$. By means of these values, it is then possible to obtain the magnitudes of the vectors $\overline{P}_1$ and $\overline{P}_2$ of the vector parallelograms in which φ_1, β_1, $\overline{A}_1$; φ_2, β_2 and $\overline{A}_2$ are known (see Fig. 4).

A drawing from a photographic recording of a typical spiral trace is reproduced in Fig. 5.

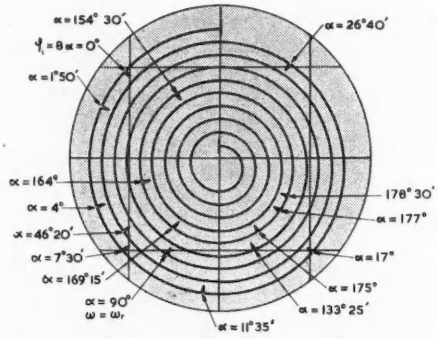


Fig. 5. **Typical spiral trace showing pulses for determining the positions of φ_1 and of various values of α.**

Comparative tests on a 2,500 kVA dynamo-alternator group, running at 750 rpm, were carried out with oscilloscope circuits giving linear, circular and spiral traces. The results can be summarised as follows:—

Relative error	Linear trace	Circular trace	Spiral trace
$100 \times (\varphi_1 - \varphi_{10})/\varphi_{10}$	3·0%	0·9%	0·1%
$100 \times (P_1 - P_{10})/P_{10}$	3·1%	1·2%	0·3%
$100 \times (\varphi_2 - \varphi_{20})/\varphi_{20}$	2·9%	0·8%	—
$100 \times (P_2 - P_{20})/P_{20}$	3·4%	1·1%	0·2%

Similar tests on a synchronous 27,000 kVA alternator with a vertical shaft, using the three different types of traces, confirmed the increased accuracy achievable with the spiral trace.

The Dynamic Capacitor as a Measuring Element

By A. STROJNIK. (From *Elektrotehniški Vestnik*, Vol. 19, Nos. 1, 2 and 3, pp. 10-15 and 39-47, 18 illustrations.)

FOR the measurement of small charges, d.c. voltages and direct currents, successful use has been made of mechanical electrometers, galvanometers and electronic instruments. Although electronic instruments are more sturdily designed than highly sensitive galvanometers, etc., their measuring sensitivity is limited by the grid current, which is at least equal to 10^{-14} A in electronic valves, and by the arbitrary shift of the anode potential as a result of the thermal processes occurring inside the valve.

The only manner in which the latter disadvantage can be fully avoided is by converting d.c. quantities into a.c. quantities. Previously, this conversion was generally achieved by means of a system with vibrating contacts (Figs. 1a, b, c) or with a periodically variable resistance (Fig. 2).

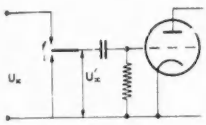


Fig. 1a

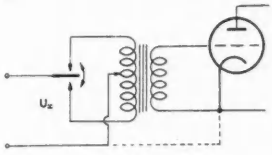


Fig. 1b

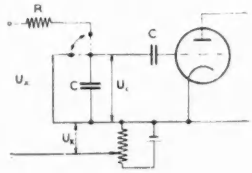


Fig. 1c

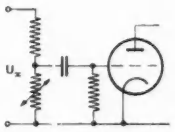


Fig. 2

The use of the dynamic capacitor has opened up new possibilities. Its principle will now be explained by means of the simple circuit shown in Fig. 3.

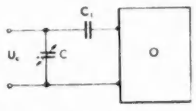


Fig. 3

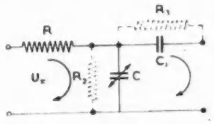


Fig. 4

If C_o is the value of the capacitance C under stationary conditions, then the relation between voltage U_c, charge Q and capacitance C_o is : $U_c = Q/C_o$.

When the capacitance is varied by dC, the corresponding voltage variation produced by the capacitor is given by

$$-dC/C_o^2 = dU_c/Q \text{ or } dU_c/U_c = -dC/C_o.$$

Consequently,

$$Q = -C_o^2 dU_c/dC.$$

The voltage U_c and the charge Q can therefore be determined from the relations

$$U_c = -C_o dU/dC \text{ and } Q = C_o U_c$$

the value of dC being known from the mechanical design of the capacitor and dU being obtained by measurement. By inserting a series resistance on the input side of the circuit (Fig. 4), the corresponding current can be determined. For instance, using a resistance $R = 10^9$ ohms, the circuit will measure currents of less than 10^{-12} A and potentials of 10^{-3} V.

It should be noted that the condenser should not be operated at a frequency near or above the resonant frequency of the system, which is $f = 1/(RC_o)$, in order to obtain correct readings.

The capacitance can be varied in several ways. The capacitance is determined by

$$C = \epsilon_o \epsilon_r S/d$$

where ϵ_o = permittivity of vacuum, ϵ_r = relative permittivity of dielectric, S = area of one plate, d = distance between plates. Thus, the value of C may be altered by varying the value of ϵ_r, S or d.

If the plate area is varied periodically, so that

$$C(t) = C_o[1 + a \sin \omega t]$$

the alternating voltage will be

$$u(t) = Q/C(t) = U_x/[1 + a \sin \omega t]$$

The peak values are then

$$u_+ = U_x/(1 - a) \text{ and } u_- = U_x/(1 + a)$$

Therefore, the peak-to-peak value of the alternating voltage produced is

$$\Delta u = u_+ - u_- = 2U_x a/(1 - a^2)$$

For a dynamic capacitor with a capacitance varying by, for instance, ± 80 per cent, this gives

$$\Delta u/U_x = 2 \times 0{\cdot}8/(1 - 0{\cdot}8^2) = 4{\cdot}44.$$

Thus, the capacitor with a variable plate area will produce an alternating voltage about 4 times greater than the input d.c. voltage. However, a capacitor of this type is more difficult to manufacture than one with a variable distance between the plates.

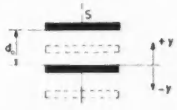


Fig. 5

The dynamic capacitor with a variable interspace (Fig. 5) has a capacitance

$$C(t) = (\epsilon_o \epsilon_r S/d_o) \Big/ [1 - (A/d_o) \sin \omega t]$$

$$= C_o \Big/ [1 - (A/d_o) \sin \omega t]$$

Hence, the alternating voltage produced is given by

$$u(t) = Q/C(t) = U_x[1 - (A/d_o) \sin \omega t]$$

and the relative peak-to-peak value is

$$\Delta u/U_x = (u_+ - u_-)/U_x \simeq 2A/d_o.$$

Therefore, $U_x = d_o \Delta u/(2A)$. The frequency f_o of the capacitance variation is chosen so that $RC \gg 1/f_o$. If, for example, $f_o = 10$ cps, and $C = 40$ pF, we must have : $R = 2{\cdot}5 \times 10^9$ ohms. A high resistance of this order requires careful insulation.

The dynamic capacitor with variable interspace is used in the circuit of Fig. 6.

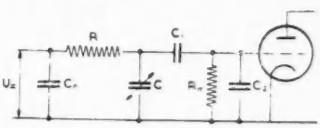


Fig. 6

Since the accuracy of measurement depends on the stability of the oscillation frequency and amplitude, which, generally, are not absolutely constant, it is preferable to use the dynamic capacitor as a zero indicator. The compensation of the measured voltage U_x is achieved either manually, by means of a compensator (Fig. 7a), or automatically, using a negative feedback (Fig. 7b).

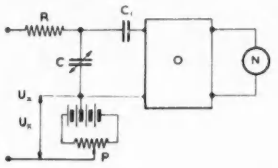


Fig. 7a

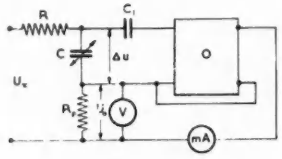


Fig. 7b

The accuracy of measurement can be assessed as follows :—Theoretically, $U_x = U_o$. In practice, when used as a zero indicator, the dynamic capacitor produces the alternating voltage $\Delta u = (U_x - U_o)2A/d_o$, U_o being nearly equal to U_x. If the amplifier has a gain equal to K, then, referring to Fig. 7b, we may write

$$K\Delta u = U_o = (U_x - U_o)2AK/d_o$$

or

$$U_o = U_x(2AK/d_o) \Big/ [1 + (2AK/d_o)]$$

If, for example, $K = 1000$ and $2A/d_o = 0{\cdot}5$, a simple evaluation of the above equation for U_o shows that the accuracy is of the order of 0·1-0·2 per cent. This indicates that a high measurement accuracy is obtained, which is only limited by the characteristics of the output meter.

The lower sensitivity limit for short-time measurements of charges and voltages is given by the electronic noise in the input circuit and in the first amplifier valve.

Variations in the contact potentials of the capacitor plates cause irregular disturbances, which, however, can be reduced to values below 10^{-4} volts. Using a resistance R equal to 10^{13} ohms, it is, therefore, possible with the dynamic capacitor to measure currents as low as $10^{-3}/10^{13} = 10^{-16}$ amperes with satisfactory accuracy.

The dynamic capacitor is particularly suitable for the determination of ionisation currents and photocurrents, as well as for pH measurements. It has the disadvantage of not recording frequencies correctly in the vicinity of the resonance frequency or above this frequency. Furthermore, as it is not an all-electronic but a mechanical-electronic device, its cost of manufacture is relatively high.

PRACTICAL RULES FOR THE ADJUSTMENT OF AUTOMATIC CONTROL PROCESSES

(*Concluded from page 260*)

the dead time-lag T_t is by converting all the equations into frequency-dependent equations.

Assuming arbitrary values for T_t, these two equations can be evaluated and lead to curves of the types shown in Fig. 1.

Transformation for an uncompensated path

$$1/c = T_S/V.$$

Transformation for an integral controller

$$c = c_R V_S.$$

Equation of controller circuit for integral controller or for a path without compensation

$$pc\, e^{-pT_t} + (c/T_n)\, e^{-pT_t} + p^3 T_S + p^2 = 0.$$

This equation can be treated in exactly the same manner as the equation of the control process without compensation. The derivation of the formulae for controllers consisting of oscillating systems is given in the author's book: "Continuous control processes," p. 90 et seq., Hanover, 1949.

Frequency equation of a control circuit with a dead time-lag:

$$F = e^{-pT_t}$$

where p = complex frequency parameter.

Equation of the control circuit

$$\underbrace{\frac{V}{1 + pT_S}\, e^{-pT_t}}_{\text{controlled path}} \underbrace{\left(1 + \frac{1}{pT_n}\right)}_{\text{controller}} = \underbrace{-1}_{\text{closing condition of circuit}}$$

from which it follows that

$$pVe^{-pT_t} + (V/T_n)\, e^{-pT_t} + p^2 T_S + p = 0$$

At the stability limit, permanent oscillations occur: $p = f(\omega)$.

With $e^{-i\omega T_t} = \cos \omega T_t - i \sin \omega T_t$ we then obtain the two equations

$$V \cos \omega T_t - \frac{V}{\omega T_t}\left(\frac{T_t}{T_n}\right) \sin \omega T_t + 1 = 0$$

$$V \sin \omega T_t + \frac{V}{\omega T_t}\left(\frac{T_t}{T_n}\right) \cos \omega T_t - (\omega T_t)\left(\frac{T_S}{T_t}\right) = 0$$

CHEMICAL EFFECTS IN INTERNAL COMBUSTION ENGINES

(*Concluded from page 257*)

possible to allow the engine to run for an indefinite period, until wear or danger of fatigue fracture enforce the replacement of certain component parts.

It should be possible to achieve this aim by studying under practical operating conditions the obscure chemical processes which have been briefly outlined; by gaining increased knowledge of the materials and the design and operating factors involved in these processes; and by properly choosing and making careful use of the lubricating medium, which, according to modern conceptions, not only has to fulfil its primary and secondary functions (lubrication and cooling), but must serve as an internal cleaning medium as well[3].

(3) J. J. Broeze: The Future of the Marine Diesel Engine, *Schip en Werf*, Jan. 7, 1949, p. 1.

ENGINEERING MARINE & WELDING EXHIBITION

(INCORPORATING FOUNDRY TRADES' EXHIBITION)

The 18th Engineering, Marine and Welding Exhibition, incorporating the Foundry Trades' Exhibition, organized by F. W. Bridges & Sons Ltd., with the patronage and active support of The British Engineers' Association, The Society of Motor Manufacturers and Traders, The British Electrical and Allied Manufacturers' Association, The Institute of Welding and The British Acetylene Association, will be held at Olympia, London, from August 30th to September 13th. More than 500 firms will be displaying their products at the Exhibition, which will demonstrate many of the latest achievements of British engineering and manufacturing techniques.

The exhibits of the Department of Scientific and Industrial Research will illustrate the importance which is attached to scientific research by British industry, and the manner in which the applied scientist is co-operating with the engineer to maintain industrial efficiency and the quality of British products.

Brief description and details of some important exhibits are given in the following preview.

Automotive Products Company Ltd., Tachbrook Road, Leamington Spa, will exhibit a complete range of Lockheed industrial hydraulic equipment. This includes a hydraulically-operated controller with the necessary control valves and slave cylinders, which latter have capacities up to 5-tons thrust, suitable for sequence operation of valves and other mechanisms, such as coke dischargers from coal carbonisation retorts and similar cyclic operations. The fan and boiler damper operating equipment will also be exhibited, including hydraulic servo equipment, etc.

In addition, there will be shown on this stand examples of the Borg & Beck industrial clutches, Rockford clutches and power take offs, Lockheed-Avery flexible hoses and self-sealing couplings, and Purolator metal element filters for all fluids in common use.

British Insulated Callender's Cables Ltd. will be displaying a range of electrical products including Ship Wiring Cables, Silicone Rubber Insulated Cables and Flexibles, Welding Flexibles, Copper Busbars with Supporting Cleats, and a Wire Rope Parting Machine.

On the display stand will be a representative selection from the wide range of BICC cables and conductors suitable for all normal requirements aboard ship. The cables satisfy all relevant clauses in Lloyd's Register of Shipping Rules for Electrical Equipment or other recognised specifications. Cables with conductors to American or Continental standards can also be supplied.

A comprehensive range of types and sizes is produced, including types with varnished cambric, impregnated paper, vulcanised rubber and fire-resisting insulation. Finishes include sheaths of lead alloy and the alternative lighter tough fire-, oil-, and moisture-resisting polychloroprene compound.

The ability to withstand extremes of temperature, from —50° C to 120° C under continuous operation, makes silicone rubber extremely valuable as a cable insulant. Retaining its dielectric qualities and elasticity at sustained working temperatures, this insulant does not flake, crack or smell, and is not seriously affected by oil.

Cables and flexibles cords with conductor size to B.S. 7-1946 are produced and suitable applications include thermocouple leads, connections in boiler houses, wiring in ships' engine rooms, boiler room spaces and galleys, and leads for jet and gas-turbine engines.

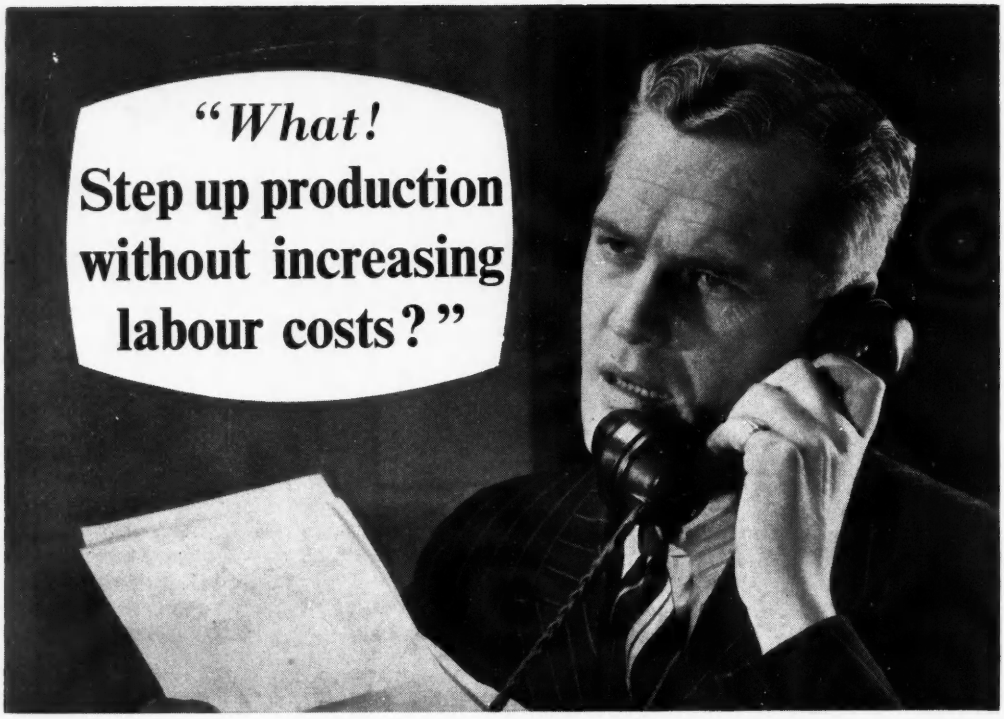
A representative selection of BICC welding cables will be displayed. They are tough rubber sheathed to give a combination of robustness and flexibility, and the wide range produced covers all normal or heavy-duty hand welding jobs. All cables are manufactured to the latest standard specifications.

Copper Busbars will be featured on the stand and, in addition, typical medium-voltage insulated supports of robust design for heavy-current busbars.

A Wire Rope Parting Machine will be seen in operation. It is the first of its kind to be marketed and parts wire ropes in such a manner that the ends are sealed and left in a tapered form—thereby greatly facilitating threading through blocks or pulleys and the subsequent clamping. The length of time required to part wire ropes varies from about 45 seconds to 2 minutes, these times comparing with between twelve and twenty minutes required for former processes of wire rope parting.

The British Oxygen Co. Ltd., Bridgewater House, Cleveland Row, London, S.W.1, will exhibit Oxy-Acetylene Welding and Cutting Equipment, including the DH. and CH. general purpose Blowpipe, the Nos. 1, 2, 3 and 5 Cutogen Hand Cutters and the Cutogen No. 4 Combined Welding and Hand Cutting Blowpipe.

Cutogens No. 3 and 5 are *two noteworthy new models* which will be available for display and demonstration. No. 3 is a heavy duty blowpipe for cutting thick sections of steel and cast iron and the No. 5 is a robust general purpose cutting blowpipe which can be used for the majority of manual cutting operations and can also be supplied with nozzles suitable for gouging, rivet-



"Sure, I can prove it, here's one way. In many Industries it is achieved by working machines faster instead of for longer hours ; and the greater the speed the greater the need for Tecalemit Automatic Lubrication."

The result of over 25 years of experience has shown us the necessity for specialised systems for particular needs — from Rolling Mills to Sewing Machines. These systems have been developed to give the correct quantity of oil or grease at the correct interval of time.

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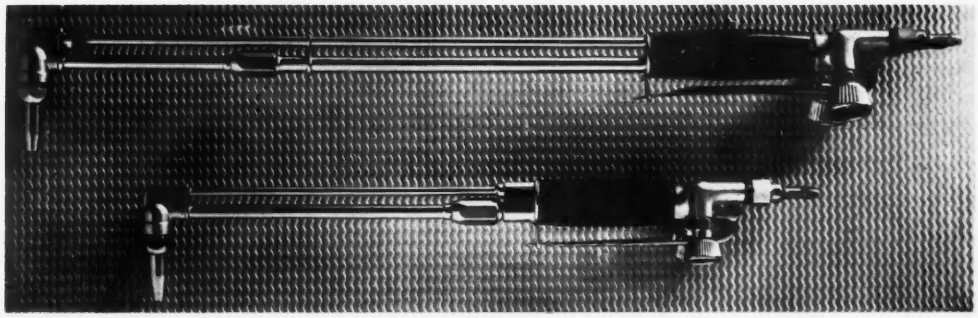

Cutogen No. 3 and No. 5 Blowpipes.

washing, etc. In addition to this range of popular general purpose equipment, Oxy-Acetylene Lead Burning outfits with the Model " O " light duty blowpipe will be shown. This blowpipe is also suitable for welding small sections (zinc base die castings, etc.).

The latest P.E.P. (Plate Edge Preparation) Machine fitted with the Multifloat Attachment will be demonstrated and plate edge preparation on curves may be observed. This combination, which is drawing the interest of Shipyards and Constructors throughout the United Kingdom, is used for preparing the edges of ships' plates, etc., for welding by the simultaneous sizing and cutting of bevels and nose on the plate edges. With four machines running on a suitable track, all four sides of the plate can be cut at the same time. With the Multifloat type of machine, curves can also be cut on one or more of the plate edges whilst the other cuts are in progress. The correct edge form, double or single bevel, etc., is maintained during the cutting of the curve.

Other cutting machines on view and to be demonstrated will be the 55 in. and 36 in. U.C.M.'s (Universal Cutting Machine) and the P.S.L. (Portable Straight Line) Cutting Machine.

Portable Welding Outfits, consisting of Blowpipes, Regulators, and Oxygen and Acetylene Cylinders mounted on lightweight trolleys, will be displayed.

Rods and Fluxes for welding, building up and hardfacing will be available for most ferrous and non-ferrous metals and the majority of alloys in both classes.

Demonstrations and advice will be given on the use of any of these rods in addition to demonstrations of a general nature covering all classes of fabrication and repair work.

Equipment obtainable under the B.O.C. Service Exchange System will be on view and will include Regulators, Gauges, Blowpipes, etc.

The Argonarc Process will be featured together with the latest additional equipment, which includes amongst other things a Water Cooled Shield on the Mark III Torch for continuous heavy duty work. The Mark III Water Cooled Torch and the C.P.U. 300Q and M.G. 300 Power Units will be used for demonstration purposes. Demonstrations will be given on Aluminium Alloys, Magnesium and its alloys, Copper, Stainless Steel and Heat Resistant Nickel Alloys. The A.W.M. 3 Automatic Argonarc Machine will also be shown.

Free technical literature covering the many processes to which the equipment is applicable will be available.

The British Thomson-Houston Co. Ltd., Rugby, is exhibiting on two Stands at this year's exhibition.

The exhibits on Stand No. 5, Row N, are representative of BTH practice in electric propulsion equipments; ships' electrical auxiliaries; Marine Radar; and many kinds of electric plant for dockyards, and general industrial use. The exhibits range from a 12-ton gearwheel as used with geared-diesel propulsion units incorporating BTH electro-magnetic couplings; developments in gas turbines; and high breaking capacity switchgear for marine service, down to electric speed indicators and magnetos for marine engines.

The industrial equipment on this stand incorporates various types of electric motors, including a new range of totally-enclosed fan-cooled machines with standardized dimensions; electric control gear; thrustors; and suds pumps. There are demonstrations of " Stacreep " (Patented) A.C. crane control, and " Clearcall " industrial communication equipment.

Mazda lamps and lighting equipment in wide variety for marine and industrial use, form another particularly attractive feature.

Control panels for spot and seam welding machines are shown on Stand No. 15, Row V, Empire Hall. They include a selection from the extensive BTH range of synchronous control panels and comprise an ignitron contactor unit utilizing two BK24/5552 ignitrons with a maximum rating of 1,200-kVA; an ignitron panel for the control of welds up to half-cycle duration; and a synchronous panel using thyratrons, instead of ignitrons, for welding machines up to 10 kVA.

In addition to other items, such as a differential water flow and air pressure switch, and several sectionalised ignitrons, there are interesting demonstrations of the BTH halogen vapour leak detector, which is invaluable for testing welded tanks, pipes, etc., and a very high-speed (25,000 counts per min.) photo-electric counter.

J. Brockhouse & Co. Ltd., West Bromwich, will exhibit a large range of general engineering products which will include Drop Forgings (from a few ozs. to 150 lbs.); Iron Castings (up to 2 tons); Steel Castings (up to 6 tons); Acid-Resisting Castings; Die-Castings (Pressure and Gravity in Light Alloys); Cold Rolled Sections (ferrous and non-ferrous); Railway Carriage Iron Work and All-Steel Anvils and vices.

The manufacturing companies of the Brockhouse Organization represented on this stand include J. Brockhouse & Co. Ltd., West Bromwich; Brockhouse Castings Ltd., Wednesfield, Staffs.; John Brooks (Lye) Ltd., Wednesfield, Staffs.; R. Hunt & Son Ltd., Birmingham; Meldrums Limited, Timperley, Cheshire; Warwick Rim & Sectioning Co. Ltd., West Bromwich; Lones, Vernon & Holden Ltd., Smethwick; and Kaye Alloy Castings Ltd., Birmingham.

Brookhirst Switchgear Ltd., Chester, will exhibit a comprehensive selection of their completely new designs of a.c. and d.c. motor starters for industrial and marine service. Hand-operated and automatic starters of various types, for wall or floor mounting, will be included. The underlying principle of these new models is extreme adaptability, the basic components being so designed that from them there can be provided

One of the first of its kind in the sterling area, this Aveling-Austin type 99H road grader and leveller is a new development of the Aveling Barford Limited organization and constructed at the Invicta Works, Grantham. All the main structural members of this powerful machine are of welded design and fabricated with Lincoln 'Multiweld' electrodes.

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World's largest manufacturers of arc-welding equipment and electrodes

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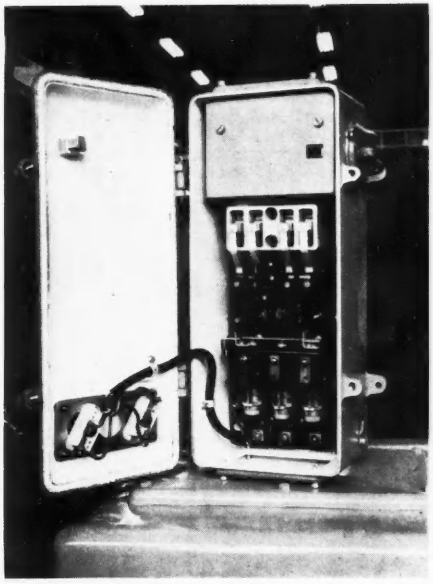


Standard Brookhirst Straight-on Starter

readily a great variety of combinations and also variety within each combination. The principal basic components, which are specially displayed, are " channel-sprung " contactors, edge-pivoted thermal overload relays, broad-base solenoid overload relays, and U-pack isolating switches. Provision is made also on standard equipments for the inclusion of many extra features (not normally available in standard short-delivery motor control equipment).

A selection of accessories such as pushbuttons, limit switches, and control switches is also shown.

A particular exhibit is a typical section of Brookhirst " Unibord " (unit-built) motor control equipment. This recently developed design is a sturdy metal-clad control board, built up entirely from standard busbar mounting units.

Burgess Products Co. Ltd., Brookfield Road, Hinckley, Leicestershire, will show " Burgess " exhaust silencers for engines up to 10,000 bhp, vacuum pumps, air and steam " blow-offs," etc. Air intake silencers for engines, compressors, blowers, fans. Air delivery silencers for pressure mains, air receivers, etc.

" Burgess " air cleaners—" oil-washed," " oil-wetted," and " dry " types—for engines, compressors, air conditioning systems, etc. Sound absorbent materials for all purposes. Sound-proof portable enclosures of all types. Acoustic telephone booths. Acoustic teleprinter and typewriter covers. Burgess " Multivent " (patent) draughtless ventilation.

Burgess micro-switches: precision limit switches, operated by 4/1,000 ounce/inches of energy, vibration-proof.

The Burgess vibro-tool, a hand-vibratory engraving tool for 250 volt, 50 cycle electric supply, and the Burgess vibro-sprayer: an electric paint sprayer will also be demonstrated.

Carter Gears Ltd., Thornbury Road, Bradford, will exhibit a fractional h.p. unit, the " Carter-Junior," showing how a compact drive of this type can be arranged by mounting the motor and gear on a special baseplate. This unit will give an infinite speed variation from motor input speed down to zero and up to full speed reverse. Flange mounted reduction gears are available for low speed requirements.

A working unit fitted with material tension and linear speed controls demonstrates a typical arrangement for application to a wide variety of reeling machines for such materials as textiles, plastics, paper, etc.

Special controls are also shown on two other units. A gear operated by electric remote control shows how inaccessible drives can be controlled from any convenient position, and another unit is fitted with the latest Servo-Control switch specially designed for use where the force required to operate the control is very light.

A unit comprising a hinge mounted motor, Carter gear, and flange mounted reduction gear complete this demonstration of the latest equipment being used in variable speed drives.

Collins' Improved Firebars Ltd., 51, The Mall, Ealing, London, W.5, will show Collins' improved firebars suitable for all types of steam and heating boilers, Lancashire, economic, verticals, sectionals, etc. Firebars are designed to suit fuel and draught. The features are maximum effective air space evenly distributed over the grate and designed to reduce small fuel falling into the ashpit. Resistance to overheating is due to the cast iron used and the design. These firebars are constructed with side ribs on a suitable deep centre rib so that the heat is dissipated from the firebar face quickly; therefore, they combine durability and efficiency with fuel economy.

Cossor Radar Limited, Cossor House, Highbury, London, N.5, will devote the main exhibit to the latest four-range Cossor marine radar of advanced technical design. This equipment comprises the scanner unit with echo box, the indicator unit, the main rack and the motor alternator.

A model of a specially designed Cossor marine radar shore-based station for harbour or ferry supervision will also be shown.

Among the principal exhibits of **Crofts (Engineers) Ltd.,** Thornbury, Bradford, will be Croft's " Ritespeed " geared motors and Reduction gears, the latest design in geared unit construction—Croft's split taper bushed V-pulleys, the latest development in V-rope driving—and the company's Patent BOM-L clutch, of much interest to machine tool makers.

A special display which will attract much attention from clutch users will be a working arrangement of mechanical clutches with emphasis on the Company's " Airflex " clutch.

Visitors will be able to see in detail all operating features of this simple and efficient clutch.

A fine example of Croft's facilities for fabricated steel constructional work will also be on show.

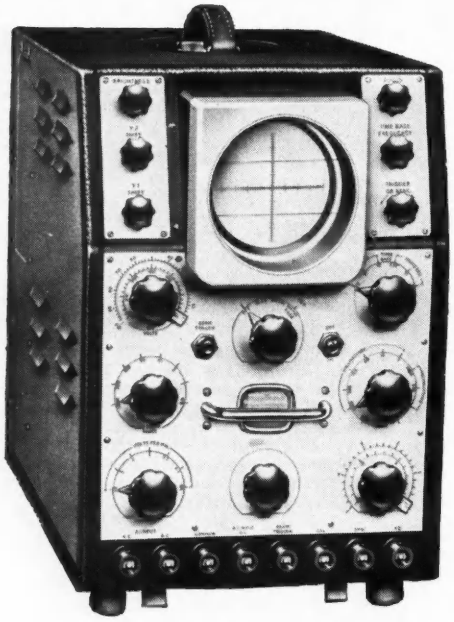
Crossley Brothers Ltd., Openshaw, Manchester 11, and **Crossley-Premier Engines Ltd.,** Sandiacre, near Nottingham, will display Crossley engines on two large island sites, side by side.

On one of the stands, four exhibits will show diesel power units for Marine, Locomotive and Stationary purposes. These exhibits will comprise a 3,000 BHP Gear Coupled Single Screw Marine Power Unit; a 1,200 BHP " Vee 8 " Locomotive Engine; a 670 BHP Marine Engine and a 400 BHP Marine Engine.

On the second stand, three large quarter-scale working models will be displayed, including particularly a Crossley-Premier 16-cylinder 2,600 BHP generating set. The stand also houses a cinema for showing the various Crossley colour/sound films.

All the two-cycle engines exhibited incorporate " Exhaust Pulse Pressure Charging," a process developed

THE COSSOR DOUBLE BEAM OSCILLOGRAPHS



Can this Instrument solve a problem for you?

Here are some details of Model 1049 as illustrated: The Double Beam Tube presents two simultaneous independent traces over the full diameter of a 90 mm. screen, and provision is made for the measurement of both input voltage and time upon the calibrated dials of the instrument. The Oscillograph is particularly suitable for obtaining permanent photographic records using the Cossor Model 1428 Camera for which a Motor Drive Attachment Model 1429 is available.

This instrument has been selected for demonstration in the Dome of Discovery (research feature) and will also be shown in the Floating Exhibition on SS. Campania.

Widely different industries are daily finding new uses for the COSSOR Double Beam Oscillograph. Sometimes it provides the answer to an industrial problem of long standing. The tracing and measurement of noise, strain and vibration are typical everyday applications of this versatile instrument which is already helping engineers in industries as far apart as brewing and the manufacture of jet engines. Call on our technical advisory staff if you have a problem. They will quickly let you know whether the Oscillograph can help you.

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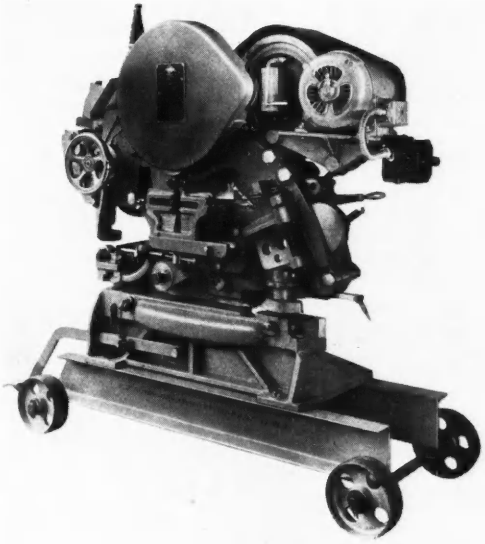
and perfected by Crossley Brothers Ltd. during the last several years, and which is now regarded as the biggest single improvement so far made in these engines.

In this process, the sudden release of exhaust gas from one cylinder is used, in the form of a steep fronted pressure pulse, to charge with air another cylinder in the line and so on in sequence. Thus, pressure charging is obtained by utilising exhaust energy which would otherwise be wasted, without paying for it either in fuel consumption or in any additional mechanical components.

Interest in powder metallurgy will be stimulated by a display of components produced by the Dueram process on the stand of **Dualloys Limited.** Starting with powdered metals—iron, copper, tungsten, etc.—die-pressed components can be produced to very accurate limits and with controllable porosity. Considerable savings in the cost of components can be effected, since the process eliminates machining. The controllable porosity is of great importance in, for instance, bearings where the liner may be automatically self-lubricating.

A section of the stand is devoted to bearings and bearing metals, including a selection of plain bearings in bronze, white metal lined with bronze or steel backs, die-cast white metal, copper-lead and lead-bronze lined with steel backs. Among the range of anti-friction bearing metals exhibited is Dencas, the high tensile chill-cast phosphor bronze.

F. J. Edwards Ltd., 359-361 Euston Road, London, N.W.1, will be showing a number of machines which have not before been publicly exhibited. Included in the display will be equipment, for which many inquiries have been received from all parts of the world including the U.S.A. The exhibit will include the following machines: Besco Production Guillotine Shearing Machine, geared, Type 36/10; Besco Production High Speed Nibbling Machine, capacity 32 in. × $\frac{3}{16}$ in.; Besco Production Inclinable Power Press, Model BA. 20 (Mark 11); Besco Production Fabricated Steel Hand Punch, Type L; Besco Production Universal Punching, Shearing, Section Cropping and Notching Machine, Type KS. 15; Besco Production Bar Cropping Machine, Type BS. 50F (Fabricated); Besco Production Guillotine Shearing Machine, capacity 36 in. × 20G; Besco Production Treadle Guillotine, capacity 48 in. × 16G.



Type KS. 15

Designed to meet heavy demands in Marine and Constructional Engineering, or in any works where large quantities of steel plate, bars and round, square, tee, channel or joist sections have to be cut to precise measurements, the "Besco" Universal Punching, Shearing, Section Cropping and Notching Machine, Type KS.15, is constructed with a robustness which increases proportionally throughout its range.

Four sizes have now been produced, the illustrated model, KS.15, being the heaviest that is suitable for portable use in the shop or on outside sites. It is powerfully built, with a body constructed of heavy cast steel sections, and fitted with high grade alloy steel shearing blades capable of splitting steel plate up to $\frac{5}{8}$ in. thickness of any length or width in successive cuts. Accuracy of operation is assured by a cutting line indicator and an adjustable hold down clamp. The blades will shear flat bars up to $\frac{3}{4}$ in. in thickness and are designed with the front end of the lower blade bevelled to facilitate mitre cutting and the notching of tee and angle sections.

Situated above the plate shears are two "slip in" blades, supplied as standard equipment, for cutting up to $1\frac{9}{16}$ in. round or $1\frac{3}{8}$ in. square bars; other shaped sections may also be cut if the blades are provided with suitable apertures. An adjustable hold-down is fitted; the blades, however, are not secured in any way, they slide into position for cutting square sections or may be reversed and returned to position when they are immediately ready for cutting rounds.

The angle and tee cropping mechanism is sited centrally in the machine, and here, sections up to 4 in. × 4 in. × $\frac{3}{8}$ in. dimensions may be cropped at right angles, while at 45° the cutting capacity is 3 in. × 3 in. × $\frac{3}{8}$ in. Self-accommodating clamps "hug" the work as it passes through the aperture, ensuring a perfectly clean and undistorted cut. The hold-down and guide is adjustable on a graduated slide for bevel cutting from 45 to 90 degrees.

The punch and notching head are arranged at the opposite end of the machine and both tools controlled by the same clutch. A rectangular notching tool is normally supplied which will also make mitre notches in angles, tees, joists, channels and plates. Precision location of the punching tool is obtained by means of a handwheel, and a stripper and adjustable guide for punching holes in the edge of steel sheet are provided.

Powered by a 3-hp motor running at 2,800 rpm giving 40 strokes per minute, mounted on top of the machine, the drive is by vee belts adequately guarded. All gearing is covered and the lubrication is by "Tecalemit" one-shot system.

Electro Dynamic Construction Co. Ltd., St. Mary Cray, Kent. Controlgear Division, Bridgwater, Somerset, will exhibit examples of marine electrical machines, including explosion-proof motors, generators, alternators and rotary converters. Power plant for radar, sound dissemination, ships' telegraphs, etc., industrial light-weight, battery traction, high-speed and electronically controlled constant speed d.c. motors will also be shown. Other exhibits will include a.c. variable speed commutator and synchronous motors, generators, alternators, frequencies 25 to 10,000 cycles, with voltage compensators, motor generators, rotary converters, power plant for electronic applications, machines designed specially for use with, or incorporated in, other equipment.

Controlgear, both hand-operated and fully automatic, for use with other exhibits, and for special purposes to customers' requirements, some with electronic features, will be demonstrated.

Magnetic Moulding Machines

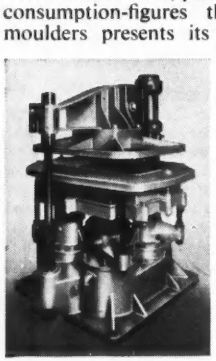
Operation and Applications

In foundries laid out for large scale repetition work moulding machines long ago proved their worth; today the advantages afforded by the Magnetic type of moulding machine are helping towards even greater efficiency and economy. These machines whilst frequently having a somewhat higher initial cost than other types of mechanical moulding machines gain by their low installation charge, negligible maintenance and the immense saving in running costs amounting to as much as £85 in twelve months.

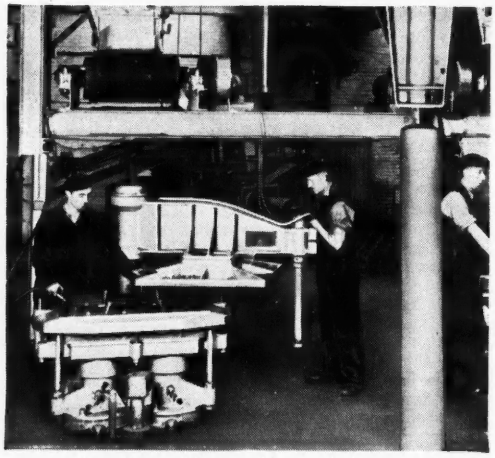
Moulding pressure in the magnetic types is applied through a D.C. solenoid. Apart from the cable connecting the machine to the power supply, there are no other connections, pipes or any exterior equipment, although a D.C. supply is of course essential. It is, in this respect, virtually self-contained, and, since there are few moving parts, requires very little maintenance.

Operation

No technical knowledge is required by the operator, for the machines are automatically controlled by a simple push-button system that is practically foolproof. When the push-button is released at the end of the pressure stroke the pattern is automatically stripped from the mould, the stripping speed being controlled by the rate of displacement of oil in the main dashpot. Electric vibrators are normally fitted which are energised momentarily immediately the "squeeze" push-button is released, to ensure that the pattern is stripped cleanly from the mould. Electric heaters (with 3-heat control switch) can be supplied to prevent the moulding sand from adhering to the pattern. The machines can usually be arranged to suit equipment already standardized for machine moulding methods. But it is, perhaps, on the evidence of power consumption-figures that the case for magnetic moulders presents its strongest argument. Unlike hydraulic or pneumatic machines where compression power must be maintained at all times throughout the shift, magnetic moulding machines only use electric power during the time the actual moulding stroke is being made—for perhaps 1½ to 2 seconds. A typical example is quoted of a magnetic moulding machine producing 350 complete moulds in boxes 20″ x 12″ x 3½″ deep, for an electrical consumption of approximately 3½ units; a remarkable figure by any comparison. When a battery of machines is in use, the electrical control includes a sequence selector device to prevent the solenoids of two or more machines being energised simultaneously, thus automatically limiting the instantaneous power demand.



Down-sand frame magnetic moulding machine.



Magnetic moulding machine producing moulds for heavy cooker-frame castings

Types of Machine and Applications

The two most popular types in current use are the "Squeeze-strip" and "Down-sand Frame squeeze strip" machines. The former has a very wide and diverse application; the latter is particularly applicable to the production of moulds for flat or shallow castings where the box depth does not exceed 6 inches.

"Double-face Boxless" and "Roll-over" types are also manufactured to meet special requirements. Slight differences in the types of machine available enable manufacturers to choose a model most suited to their particular requirements.

The field of application is wide and includes the production of moulds for the components of gas, electric and solid fuel combustion cookers and stoves; industrial and agricultural machine parts, electrical fittings and instrument components.

Magnetic Moulding Machines are made exclusively by British Insulated Callender's Cables Limited in their Prescot factory; this organization also provide the customary "After Sales Service".

For those who wish to know more about the application of Magnetic Moulding Machines in the foundry, BICC have published detailed information (Publication 276U) which is available on request to:

BI Callender's

British Insulated Callender's Cables Limited
Norfolk House, Norfolk Street, London, W.C.2

Conveyancer Fork Trucks Ltd. (Subsidiary of Electro-Hydraulics Ltd.), Liverpool Road, Warrington, Lancashire, will be exhibiting on the stand of their parent company, Rubery Owen (Darlaston) Ltd.

A Conveyancer Fork Truck Model E2-20/3W will be shown, which is an electric truck having a lift capacity of 2,000 lb at 20 in. load centre. This truck will be fitted with a 6 feet stacking unit although 9 ft and 12 ft units are supplied; it is a 3 wheel vehicle with exceptionally small turning radius of 60 in. and is thus extremely manoeuvrable. A special feature is its complete safety; overloading is virtually impossible since no traction is obtained when loaded to excess. By its direct accessibility to all components, this truck is easily and quickly maintained.

George Ellison Ltd., Perry Barr, Birmingham, 22B will show :—

Electric motor starters and control gear for slip-ring and squirrel-cage a.c. motors, electric crane control equipment, circuit breakers for circuits of up to 660 volts. A medium voltage factory distribution switchboard with draw-out circuit breakers, a high-voltage truck switchboard, limit and emergency switches and cable fittings will also be exhibited.

The English Electric Company Ltd., Queen's House, Kingsway, London, W.C.2, will exhibit :—

A.C. totally enclosed fan-cooled machines for industrial applications from 1-20 hp inclusive.

Typical d.c. machines of the ventilated and totally enclosed types for marine work.

A.C. totally enclosed short-time rated crane motors.

F.H.P. motors, from 1/20th to 1 hp, based on the standardisation of components used in combination to build many thousands of motors, differing electrically or mechanically. Drip-proof, totally enclosed or totally enclosed fan-cooled motors are available with solid or resilient bases, flange or lug mounting, covering the majority of requirements for many varying applications.

A full range of fusegear in all its applications to light and heavy engineering.

The exhibit by this company's Diesel Engine Division comprises power units for the industrial and rail traction fields.

A unit of particular interest is the 38-ton 938 bhp 5SRL type diesel engine which operates at 275 r.p.m.

The selection also includes a 4RKD type dual fuel engine alternator and exciter. This 220 dhp engine operates on town, natural, producer or sewage gas, and can be changed from diesel to dual fuel operation while running.

The 6-cylinder " H " type engine, rating 220 bhp at 1,500 rpm, is shown as a package type unit and is designed for operation on oil well drilling rigs.

The company's traction range is represented by the 16-cylinder turbo-charged 2,000 bhp " SVT " type diesel engine having a speed range of 420-850 rpm

Further exhibits include models and a photographic display featuring other engines.

An outstanding exhibit of the **English Steel Corporation Ltd.** will be a machined Forged Gear Wheel Rim 11 ft 9 in. diameter, weighing 7½ tons. This massive steel ring is follow-forged from a solid ingot and has no welds or joints. To make four such rims a 120 ton ingot is required and only forging presses of exceptional size can forge ingots of this weight.

Another exhibit which will no doubt be of interest to marine engine builders is the R.R. Continuous Grain-flow Crankshaft. This crankshaft is press-forged by a new forging process and although it possesses all the characteristics of a drop forging it would be quite outside the scope of any British drop forge.

Briefly, the advantages of this new technique in the forging of large crankshafts are :—

1. Continuous grain-flow is ensured through all sections of the crankshaft, giving considerably greater strength.
2. Minimum of machining necessary on crank pins, journals and webs, and periphery of the webs may be left unmachined if desired.
3. Crank throws are formed at their correct relative angles without any twisting of the journal.
4. Flanges may be upset, giving correct grain flow.

The crankshaft exhibited is 10 ft long, weighs 1½ tons and has pins 6½ in. dia. turned. It is partly sectioned and etched to show grain flow and has two throws machined and two left in the " as-forged " condition. Sole British rights for the manufacture of crankshafts by this process have been acquired by English Steel Corporation Ltd.

A fine example of the Marine products of E.S.C. is a Propeller Shaft Forging 23 ft 6 in. long fitted with bronze liner.

Drop forgings for marine engines are represented by an 1100 lb crankshaft in the " forged " condition, and a selection of smaller finished crankshafts.

In the general engineering line are shown a forged steel drill collar and " Substitutes," for oil well drilling plant.

Products of the works at Openshaw, Manchester, and Holme Lane, Sheffield, are shown in attractive displays of Engineers' Cutting Tools, Magnets and Files and Hacksaws, backed by photographs of manufacturing processes. There is also an interesting display of old hand-cut files, some more than 100 years old, and unusual types of files rarely seen today. From Openshaw Works there is shown a range of Rock Bits for Oil Well Drilling, a type which until recently was manufactured only in the United States of America.

The stand of **The Esso Petroleum Co. Ltd.,** Queen Anne's Gate, London, S.W.1, will be devoted to automotive, aviation, marine and industrial fuels and lubricants, diesel fuels and lubricants, heating oils, fuel oils, industrial lubrication service, cutting oils, drawing compounds, chemicals and solvents, bitumen, scale and wax.

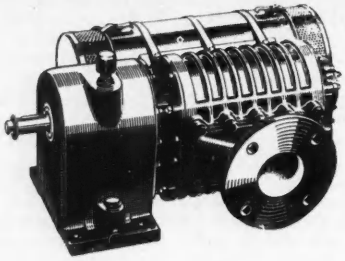
A working exhibit showing the principle of operation of the Trabon centralized lubrication system is one of the features on the stand of **Exactor Limited.** The exhibit demonstrates the way in which measured charges of lubricant—either oil or grease—can be regularly and automatically fed into a whole series of bearings on a single machine, or a group of machines, from a central control. The system ensures that a bearing cannot be by-passed, and in the event of a choked feed, visual warning is immediately given at the control point.

In a display devoted to industrial hydraulics, Exactor emphasise their role in the design, development and production of all types of hydraulic equipment for machines ranging from bulldozers and scrapers to fork trucks and cranes.

Another exhibit is the self-sealing pipe coupling. These couplings allow an oil—or other liquid—pipeline to be broken at the coupling point without a drop of the liquid being spilled. Re-coupling is equally rapid and similarly free from spillage. Exactor pipe couplings find their principal application in aircraft, ships, agricultural equipment, chemical works and public utility services.

On the Exactor stand appears one of the first models from the U.S.A. of the Wilkerson Valve, which is claimed to solve the long-standing problem of dry, and clean, air lines. The valve is installed in compressed-air lines and automatically expels all water condensate, oil, grit, rust and sludge.

INDUSTRIAL BLOWERS



Clean and variable air flows with displacements of 10-8,000 c.f.m. at pressures up to 10 p.s.i.

MARSHALL

(ROOTS TYPE)

INDUSTRIAL BLOWERS

VACUUM PUMPS

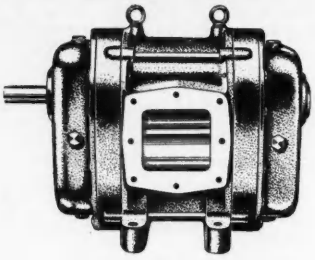
SUPERCHARGERS

GAS BOOSTERS

STAND 45
Outer Row, Gallery,
Grand Hall.

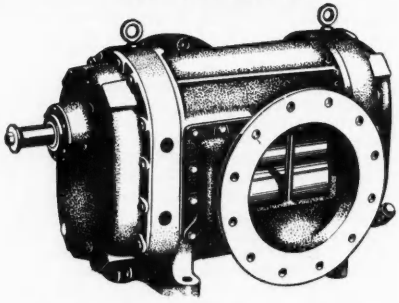
Many years of experience in in dustrial practice have enabled us to widen the application of the Roots principle, to meet the various requirements in industry for blowing and exhausting air or gas, and engine supercharging.

VACUUM PUMPS



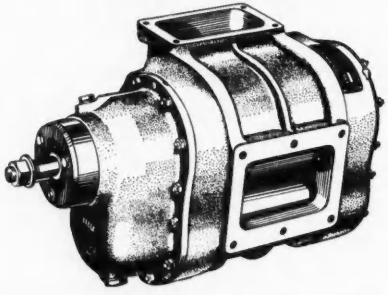
Delivery to 15" Hg. vacuum. Versatile performers, capable of blowing or exhausting.

GAS BOOSTERS



Suitable for boosting Towns Gas and commercially used gases. Special sealing arrangement and the provision of safety ventilation.

SUPERCHARGERS



For pressure charging of four-stroke Diesel and petrol engines, also scavenging and boosting 2-stroke oil engines.

Sir George Godfrey & Partners (Industrial) Limited

HAMPTON ROAD, HANWORTH, MIDDLESEX, ENGLAND.

Tel.: FELtham 3291/5 (Head Office and Works) FELtham 4037/8 (Sales, Service, Publicity)

Cables: Godfrepart, London.

Fibreglass Limited, Ravenhead, St. Helens, Lancashire, will demonstrate all forms of heat, sound and electrical insulation, with particular emphasis on the many forms of "Fibreglass" manufactured for heat insulation in the marine field.

Flexible Drives (Gilmans) Limited, Carlton House, 195, High Street, Smethwick 41, Staffordshire, will demonstrate a complete range of flexible drives, flexible drive machines and accessories, which are used for boiler scaling, tube and surface scaling, rust and paint removing, etc., also smaller machines, which are used for rotary filing, milling, wire brushing, polishing, etc.

A full range of rotary milling cutters and files will also be on view.

From the comprehensive range of a.c. welding plant manufactured by **The General Electric Co. Ltd.,** portable single-phase and twin-arc welding sets will be on view.

The portable twin-arc equipment represents the most outstanding advance in a.c. welding plant in recent years, and is the outcome of exhaustive experimental and development work which was undertaken with a view to producing a.c. welding equipment which would take a balanced three-phase load from the supply at a high power factor, without the additional expense of a power factor correcting capacitor.

By using an arrangement of two parallel electrodes insulated by their normal flux coating and fed from a three-phase to two-phase transformer, the whole of the arc energy is concentrated into successively burning arcs from each electrode tip to the work piece. Only a very small (single-phase) component of the current bridges the gap between the electrode tips.

Furthermore, since ionisation due to the burning arc from one electrode assists in re-striking an arc from the other electrode, and also because temperature fluctuation in the arc zone is reduced, the open circuit secondary voltage (normally about 80 volts) is much lower with a corresponding improvement in power factor. With the majority of electrodes, a secondary voltage as low as 45 volts is possible, while the average power factor is of the order of 0·55.

As a direct result of the improvement in arc stability the arc is quieter and much more easily controlled, so that it is difficult even for a novice to deposit a bad weld.

Again, due to the improved thermal efficiency of the two-phase arc, and the fact that a larger total cross section of electrode can be used for a given size of weld, the rate of deposition as compared with single-phase welding is from 20 per cent to 50 per cent faster, depending upon the size and type of weld being produced. A further improvement in welding speed arises from the fact that twin electrodes of standard lengths deposit about 70 per cent greater length of weld metal than equivalent single rods, with a consequent considerable saving in time for rod changing. Experience has shown that on a $\frac{5}{16}$ inch fillet weld, the total saving compared with single arc welding is of the order of 45 minutes for each 100 feet of welding, 30 minutes being due to greater welding speed, and 15 minutes to less frequent rod changing.

Although the G.E.C. equipment is intended primarily for service as a twin-arc set, it can be used as a normal double operator unit with independent control for each welder. For this purpose, a voltage change-over switch is provided which gives 45 volts or 60 volts on the secondary terminals, the higher voltage being provided for single arc welding. This feature is useful when special types of electrodes are necessary or when the equipment is used for tacking and intermittent welding operations in very confined spaces.

Demonstrations of the operation of the twin-arc set will be given. These will enable direct comparisons to be made between the performance of this type of plant as compared with the more usual single-phase equipment. For this purpose, simultaneous welds will be made by two operators using twin-arc and single-phase sets, and a continuous indication of their relative performances will be seen on an instrument panel.

Arrangements are now in hand between The General Electric Co. Ltd., and The Quasi-Arc Co. Ltd., whereby the latter company will become the sole concessionaires for the equipment.

Sir George Godfrey & Partners (Industrial) Ltd., Hampton Road, Hanworth, Middlesex, will exhibit Marshall industrial blowers, vacuum pumps, gas boosters and superchargers to meet industrial requirements for blowing/exhausting air or gas. Delivery from 1-6,000 cfm (170 m^3/min) pressures up to 10 psi (0·71 kg/cm^2) and 15 in (381 mm) Hg vacuum.

The operation of the blowers will demonstrate the principle of positive rotary displacement. Sectioned exhibits will show the internal arrangement of blowers using two or three lobed rotors. Diagrams, photographs, brochures, etc., will be displayed in order to impart full technical information and application of the firm's products.

Hancock & Co. (Engineers) Ltd., Progress Way, Croydon, Surrey, will exhibit oxygen cutting machines of all types for shaping steel for all purposes. Other exhibits include: "U" arm general purpose machine with five drives, a longitudinal profiling machine with electronic tracer for accurate and automatic reproduction direct from a drawing, a portable machine for cutting straight lines and circles, and a flame planing machine for plate edge preparation. Pipe cutting machines and an entirely new profiling machine with many new and useful features will also be exhibited.

Hoover Limited, Perivale, Greenford, Middlesex, will show the new Hoover F.H.P. motor, which incorporates the most up-to-date features of motor design and manufacture.

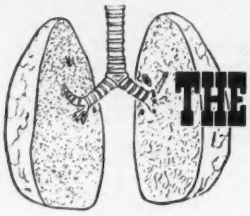
The standard range of motors comprising $\frac{1}{8}$ to $\frac{1}{2}$ hp single-phase and $\frac{1}{8}$ to $\frac{3}{4}$ hp three-phase is well suited for driving machine tools, refrigeration equipment, industrial sewing machines, air conditioning plant, compressors and pumps.

In support of the motor is a sales service organisation to give advice on manufacturers' motor problems and to cater for the repair of motors.

The Incandescent Group, Cornwall Road, Smethwick, Birmingham, comprises The Incandescent Heat Company Limited, Metalectric Furnaces Limited, Controlled Heat and Air Limited, Selas Gas and Engineering Co. Limited, and Metal Porcelains Limited.

A complete range of photographs will be shown, illustrated by models covering metallurgical furnaces and ancillary equipment for all industries, fired by solid fuel, gas, oil and electricity. This includes complete vitreous enamelling, bright brazing and annealing, galvanising, normalising, hardening and tempering, gas carburising, malleableising plants, complete mechanised sheet and strip rolling mill equipment, foundry equipment, arc melting furnaces, induction heating equipment, continuous and static drying ovens for all processes, including tin printing, core and paint drying, gas and oil burners, valves, air-gas mixing apparatus, aluminium melting, laboratory heating equipment, vitreous enamel frits, oxides, etc.

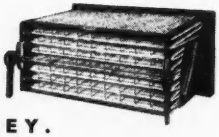
Exhibits of the **Lincoln Electric Co. Ltd.,** Welwyn Garden City, will include several recent developments, including Lincoln's new electrodes Multiweld and Positionweld, which will have a special display. The electrode, Fleetweld 5, will also have a special position.



THE NATION'S MANPOWER needs this protection

Just as the filtration of the air which the workers breathe safeguards their health, so does the filtration of the air consumed by machines provide a valuable insurance against breakdown and needless depreciation. In thirty years of constant development nothing has been found to improve upon the basic principles of VOKES filtration, and today the degree of protection afforded to man and machine by VOKES filtration remains unsurpassed. Remember too—rigid adherence to the stated servicing periods and the replacement of elements when necessary ensures that the unrivalled efficiency of VOKES filters is maintained. Full details of the VOKES range for all air conditioning applications will gladly be supplied on request.

VOKES *Pioneers of scientific filtration*



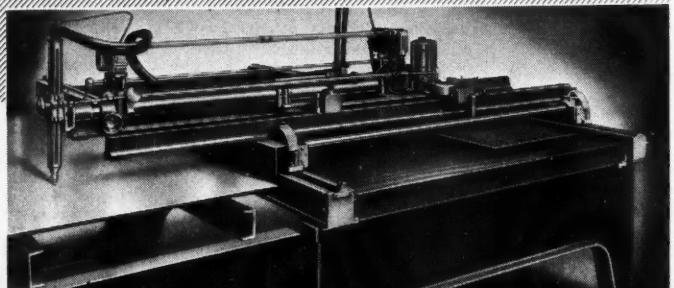
V52

VOKES LTD. Head Office: GUILDFORD, SURREY.
London Office: 40 Broadway, Westminster, S.W.I.

Vokes (Canada) Ltd. Toronto *Represented Throughout the World.* *Vokes (Australia) Pty., Ltd., Sydney.*

A WORLD-WIDE FILTRATION SERVICE AT THE COMMAND OF INDUSTRY

HANCOCK L.P. CUTTING MACHINE



reduces cutting time on large areas.

The L.P. Machine is made in four standard sizes with cutting widths of 3ft. 5ft. 7ft. 10ft. the length in each case being 10ft. this length can be extended to 50ft. or more by additional length of rail. A second carriage can be fitted when the machine virtually becomes two machines working simultaneously on the same or two separate plates.

Particularly suited for large components where great overall accuracy is required.
Illustrated catalogue on request.

ENGINEERING MARINE & WELDING EXHIBITION Row W, Stand 9

HANCOCK CUTTING MACHINES

HANCOCK & CO. (Engineers) LTD.
PROGRESS WAY · CROYDON · SURREY Telephone: CROYDON 1908

This electrode is used almost exclusively on pipe-lines and oil refinery work throughout the world.

The Lincoln machines on display will be the SA.150 Motor Generator, SA.150 Generator, SA.200 Petrol Welder, SAE.300 Petrol Welder and fully and semi-Automatic submerged arc welding equipment, which will be demonstrated by Lincoln field engineers.

The new Lincoln SA.200 welding machine is powered by a Fordson Major 4-cylinder tractor engine which develops 38 max. bhp at 1500 rpm. The generator is a single operator variable voltage type, with complete laminated magnetic circuit (frame and pole pieces) and equipped with interpoles ; requires no exterior reactance or stabilizer. Patented dual control of welding current is accomplished by adjustment of both series and shunt fields. Supplies uniform current for arc welding in any position with coated electrodes or carbon arc welding.

A series of the latest Lincoln literature will also be on show.

Lion Leather Limited, Viaduct Works, Cavendish Street, Ashton-under-Lyne, Lancashire, will exhibit leather transmission beltings of all types : round, flat, " Scott " patent vee, link, etc., " Quickfor " patent vee belt fasteners, belt laces of all types, belt fasteners for transmission and conveyor belts, also patent fasteners for round bandings.

Hydraulic leathers of all kinds, leather washers, welders' aprons, protective clothing—gloves, etc., " Leo-Flex " rubber vee belting in open lengths, as well as endless, will also be shown.

Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. Metrovick exhibits will include :—Models of waterwheel generator and large mine winder installation ; range of vacuum pumps ; type S crack detector ; details and model of diesel-electric propulsion machinery for the new Wallasey ferry ; large-scale model of 8,000-shp geared turbine machinery being constructed for Alfred Holt and Co. Ltd. ; display of ships' lighting fittings and industrial types of lighting fittings ; some aspects of Metrovick marine gas turbine development ; demonstration of electronically controlled motor drive through continuous strip process involving tension or speed control using a dancing roller operated by a festoon in the material.

Two of the latest 60 kVA air-operated spot welders will be demonstrated. One is in its normal operating condition, the other has all covers removed.

The resistance-welding equipment includes a light-weight portable spot-welding gun of new design.

A demonstration of automatic arc welding will be provided. The automatic machine embodies an improved design of electronic control of the arc, which permits a high rate of deposition of weld metal, with corresponding high welding speeds. The coiled electrode used is one of the Metromatic range ; the welding current output is 1,000 amps.

Other exhibits include : The " Thermac " single-operator air-cooled transformer welding set, which provides smooth variation in current from 75 to 425 amps. The " Paradyne " single-operator motor generator welding set, specially designed for heavy and continuous duty. An atomic hydrogen welding set for light gauge welding, and for hard surfacing and repairing of tools and dies. A comprehensive range of " Metrovick " arc-welding electrodes and accessories.

The stand of **The Mond Nickel Co. Ltd.** will feature the history of nickel since its discovery by the Swedish scientist, Cronstedt, 200 years ago. The individual exhibits will include a model of Cronstedt's laboratory, copies of classic papers in the history of the nickel industry, and photographs and drawings of production equipment and plant. Examples of uses of nickel and its alloys will be shown. A full range of technical publications on the properties and uses of nickel and nickel alloys will be available on the stand.

The Stand of **The Morgan Crucible Co. Ltd.,** Battersea Church Road, London, S.W.11, will be devoted mainly to a display of crucibles, foundry accessories and crucible furnaces.

Of particular interest to all foundrymen will be the showing for the first time of the latest addition to the Salamander Range—the Salamander Suprex crucible—developed for use in specially arduous conditions.

This crucible will satisfy the needs of those melters who, for good technical reasons, are unable to obtain complete satisfaction from the standard type of crucible. Although such practice is not recommended, Suprex crucibles can be plunged into hot furnaces without pre-heating and resist the resultant thermal shock. They can be brought to a maximum heat very rapidly, or chilled quickly between heats. In addition, the Suprex crucible has an exceptional resistance to erosive slag, a combination of qualities which ensures a crucible with a long and consistent life.

Among the crucible furnaces on show will be the recently developed Power Tilted Central Axis Furnace (Type CA/MECH). This furnace is also being exhibited for the first time. In the power tilted model—similar in all other respects to the well-known hand tilted Morgan Central Axis Tilting Furnace (Type CA), the tilting gear is operated by an electric motor, the fixed speed pouring being controlled by means of a selector handle. Special attention has been paid to the design of the tilting gear, which is of simple design and of extremely robust construction. It is available in sizes from 400 lb in brass to ¼ ton in aluminium.

Another furnace of considerable interest is the Rotary Crucible Tilting Furnace (Type RCF). This furnace is fitted with a mechanically rotated bottle-shaped crucible specially designed for the melting of swarf and metal powders with a minimum of oxidation loss. It is recommended for melting skimmings, metal powders, residues, brass, bronzes, white metal, tin, zinc, and copper, etc.

This exhibition marks the showing for the first time of the new Morgan M.R.1 Refractory. The use of selected high-quality raw materials together with a revolutionary method of manufacture has resulted in a refractory having a greater factor of safety at high temperatures, giving longer life and reducing maintenance costs. It is rigid up to 200/250° C above any fireclay brick, is highly resistant to thermal shock and strongly resistant to slag-laden gases, etc.

Other exhibits include " Morganite " carbon engineering components and " Reservoil " oil-retaining bearings.

Perry Chain Company Limited, Tyseley, Birmingham 11, will exhibit a full range of industrial precision roller chains, samples of chain drives and universal chain couplings complete with covers.

Pilkington Brothers Limited, St. Helens, Lancashire. The exhibit is designed round a tall electric pylon which will display strings of " Insulight " toughened glass high voltage insulators of many types now available.

" Insulight " sealed double-glazing units will be given a prominent place on the Stand to demonstrate thermal insulation.

The properties of " Armourplate " glass in industrial and modern uses will also be demonstrated, whilst another feature will be painted and fire-toughened glass now applicable for a variety of uses.

" Insulight " hollow glass blocks, which possess efficient thermal and sound-insulating properties, will also be displayed.

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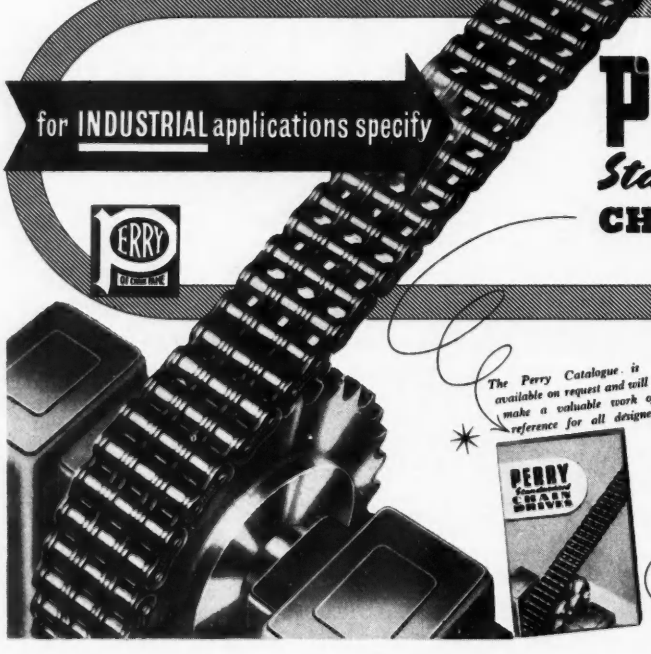

The Perry Catalogue is available on request and will make a valuable work of reference for all designers.

The benefits, technically and economically, of standardisation of Chain drives are acknowledged by all engineer-designers and the Perry Chain Drive Catalogue gives expert advice as to the selection of the most suitable standard drive for any normal application. When special circumstances arise, outside the standardised range, Perry's offer expert collaboration, based upon years of experience of roller chain application.

PERRY CHAIN CO. LTD.
TYSELEY · BIRMINGHAM · 11

Photostat Ltd., Adelaide House, London Bridge, London, E.C.4, will exhibit " Photostat " and " Statfile " equipment.

" Photostat " is known internationally as an efficient and easily operated machine for copying documents. Recent applications include protective recording of workshop drawings, records of gas and sewage mains, docks and railway sidings, colliery workings, etc.

The " Statfile " Recorder is employed for the photographic recording of all sizes of plans and drawings up to 40 in. by 60 in. The small film negatives form a vital security file, whilst projected copies on translucent materials save tracing work and costs.

Rapid Magnetic Machines Ltd., of Lombard Street, Birmingham 12, who recently celebrated their Golden Jubilee, will be exhibiting a wide range of electro and permanent Magnetic Equipment. The exhibits will include the " Permaflux " Drums and Pulley Type Separators, also a new welding clamp which is adjustable to all angles.

Two typical types of Swarf Separators, which are also fitted with permanent magnets, will be shown in operation.

Electro-Magnetic Percolators for treating wet materials such as potters slip, glaze, etc., will also be available for inspection, as will the Overband Type Separator, which is widely used in foundries for extracting iron sprigs, etc., from foundry sand. Electro Lifting magnets, Clutches and Brakes will be exhibited. Industries and trades using magnetic equipment include Foundries, Collieries, Rolling Mills, Steelworks Metal Merchants, Refineries, Chemicals, Coke Ovens, Refuse Handling, Washeries, Power Stations, Textiles, Ceramics, Plastics, Cork, Glass, Abrasives, Powder, Rubber, Minerals, Grain, Oil, Cattle Foods, Sugar, Tea, Fruits, Cereals, Seeds, Maize, Tobacco, etc.

Redifon Limited, Broomhill Road, Wandsworth, London, S.W.18, will show wireless telegraphy, telephony and direction-finding equipment for all types of vessels and shore stations. Exhibits will include full-scale replicas of wireless rooms of a modern merchant vessel and deep-sea trawler complete with transmitters, receivers, radio telephones, direction-finding loops and receivers, auto-alarms, communal aerial amplifiers for passenger ships, music reproduction and sound amplifying equipment, wave-meters, etc.

All marine radio equipment exhibited will conform to the latest specifications and revised international regulations.

Engineering exhibits will include industrial radio frequency heating of both induction and dielectric types. Demonstrations of radio frequency heating will be given frequently throughout each day on the stand. Applications engineers will be in constant attendance to give impartial advice on any problem involving the use of radio frequency heating.

Shell-Mex and B.P. Ltd., Shell-Mex House, Strand, London, W.C.2, are distributors of industrial and marine fuels and lubricants. A working exhibit will demonstrate equipment used in research into fuel and lubrication problems of modern prime movers.

Small & Parkes Limited, Hendham Vale Works, Manchester 9, will exhibit :—

" Don " industrial brake and clutch linings, new qualities, developed to meet the requirements of all branches of engineering.

" Railko " engineering bearings and laminates for stern tube bearings, water-pump bearings, etc.

Grooved " Roko " belting, warp guaranteed 100 per cent pure camel's hair yarn.

" Karmal " steam and hydraulic engine packings.

" Roko " industrial webbings.

" Don " colour-filled aluminium stairtreads for factories and marine applications.

Suffolk Iron Foundry (1920) Ltd., Sifbronze Works, Stowmarket, Suffolk, will show oxy-acetylene welding supplies and equipment including " Demon " blowpipes, regulators, goggles, hose, gloves, cylinder keys and Sifbronze range of welding rods and fluxes for all classes of oxy-acetylene welding.

Tangyes Ltd., Cornwall Works, Smethwick, Birmingham, will exhibit two of their latest types of Horizontal Diesel Engines, viz., the " WH4 " Type, capable of giving 27 bhp at 370 rpm and the " P2 " Type, a totally enclosed, completely self-contained unit, giving 9 bhp at 800 rpm.

The Tangye 25-ton Universal Testing Machine to be shown is capable of performing all types of tensile, compression, beam, shear and bending tests, and of carrying out many precision pressing operations, such as bushing, forming, straightening, etc.

This machine incorporates a new type of precision load indicator, is entirely self-contained, and requires no foundation. It is extremely simple to operate and service, and provides full protection to operator.

A 60-ton Hydraulic General Service Press, and a 16-ton Hydraulic Sleeving Press, designed for refitting and extracting cylinder liners of car and lorry engines, will be on show.

Also exhibited will be Vertical Single Ram Pumps, Centrifugal Pumps, Steam Pumps, and Hydraulic Pressure Pumps.

The exhibits will include Hydraulic Lifting Jacks and two of the Tangye Industrial Heaters.

Tufnol Ltd., Perry Barr, Birmingham 22B, will exhibit a comprehensive display of components produced from Tufnol, the non-metallic material for engineers. Exhibits on show for the first time will include the following :—

Pinion Coupling for Run-Out Table Rollers in Hot Strip Mill. The couplings are steel-encased with Tufnol pinions transmitting a load of 0·62 to 1·77 hp at 270 to 775 rpm. The working conditions are extremely poor with water and dirt in abundance, and the teeth of the pinions are rounded to take the play on the spindle. Previously, the average life of a pinion was under six months, but since using Tufnol this period has been increased to over twelve months.

Inking Roll Bearing. Used for supporting the inking roll on a printing machine, operating at 200 rpm

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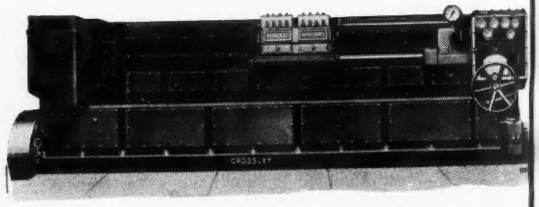

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AT THE ENGINEERING, MARINE & WELDING EXHIBITION — OLYMPIA, Aug. 30 to Sept. 13, 1951

Twin geared marine power unit	.. ..	3000 b.h.p.
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Marine propulsion engine	.. ..	400 b.h.p.

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Male and female portions of a pinion coupling (Tufnol pinion on the right) for driving the run-out rollers from a hot strip rolling mill.

this bearing is lubricated by a thick aqueous solution. Bearings previously used had a maximum life of 3 months, whereas Tufnol bearings in present use show no signs of wear after 8 months and it can be safely assumed that they have many more months of service left in them before requiring replacement.

Feed Roll for Paper Bag Making Machine. The roll is made of Tufnol and has a metal spindle. Tufnol will not splinter or split and is "kind to paper and other materials."

Interior of Logging Device for Ships. The complete instrument trails in the sea and it incorporates a Tufnol gear wheel which is unaffected by sea water and requires no lubrication.

Insulating Interior Cover Plate for Switch Fuse. Made in black fabric Tufnol, which is a good insulator, is mechanically strong and robust and will not crack when screwed down.

Other Tufnol components displayed will include a selection of gear wheels, bearings, pulleys, marine components, electrical insulators, light weight jigs and various parts for textile machinery, electro-plating plant and many other different forms of service extending into almost every industry.

Many of the exhibits have been machined to shape with the usual engineering tools from Tufnol sheets, tubes or rods. Others have been specially moulded during manufacture.

The United Steel Companies' stand will again provide a communal display on behalf of their various subsidiary and associated Companies. Prominent amongst these as suppliers of steels, in various forms and finishes, to the Marine and Engineering Industries are :—

Steel Peech & Tozer
Appleby-Frodingham Steel Company
Samuel Fox & Co. Ltd.
Workington Iron & Steel Company
United Strip and Bar Mills.

The display will illustrate the varied and modern plant in operation at their various works engaged in producing such widely differing products as strip down to 1/1000th part of an inch or slabs of up to 17 in. in thickness, with intervening sizes and sections and in a multiplicity of qualities, in addition to refined irons for foundry purposes.

A qualified staff will be in attendance at all times to discuss customers' problems. The stand will be in continuous teleprinter communication with all branches so that where necessary any enquiry or query can be referred back to the works and a speedy reply obtained.

Edgar Vaughan & Co. Ltd., Legge Street, Birmingham 4, will feature a wide range of neat and soluble metal cutting oils, drawing compounds, grinding and broaching oils. Specialised lubricants, hydraulic oils, rust preventives, industrial cleaning compounds. Also oils, salts and solid carburisers for the heat treatment of metals. Mechanical leathers for a diversity of applications will also be featured.

Technical staff will be in attendance to discuss visitors' relevant problems and recommend the best application of Vaughan products.

Vokes Limited, Guildford, Surrey, are specialists in the filtration of air, lubricating oil and liquid fuel and in engine silencing. A range of these products will be exhibited, including examples of dry fabric filters with corrugated elements (a form of construction that produces the maximum developed area and the lowest velocity of air flow through the element) and of Vokes dust recovery filter unit, which is finding increasing applications in all industries needing the elimination or recovery of process dusts on a large scale.

Vokes Genspring Constant Support Hangers will be shown in an expanded range covering all requirements for taking up thermal expansion loads on pipelines, steam pipes and so on in installations in oil refineries, power houses and ships.

Wade Engineering Ltd., Gatwick Airport, Horley Surrey, will exhibit four lobe rotor, helical port Roots type blowers for petrol and oil engines. Constant output air pumps and vacuum pumps for industrial uses. The Wade "V" type variable compression pressure charger. Wade intercoolers and air motors. Technical staff available on the stand to assist with any problems relating to supercharging or its applications.

C. C. Wakefield & Co. Ltd., 46 Grosvenor Street, London, W.1, will exhibit an extensive range of

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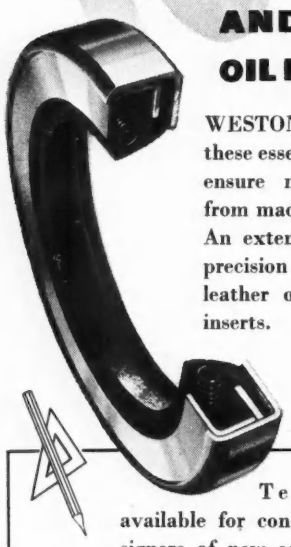

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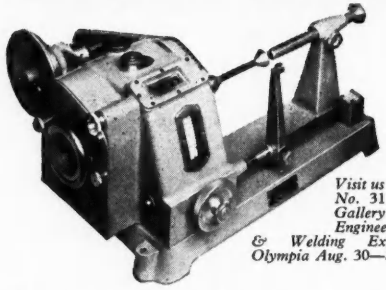

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Many refinements are embodied, previously obtainable only on elaborate machines.

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mechanical lubricators and lubricating accessories for industrial and marine uses, covering the application of both oil and grease. Experts on the stand will be able to give visitors guidance on the correct choice and application of lubricants to their own particular problems.

Weldcraft Ltd., Progress Way, Croydon, Surrey, will exhibit "Aut-o-Cet" and "Sight Feed" medium and high-pressure acetylene generators, both stationary and portable types. These generators are entirely automatic, and are made in various sizes to cover the requirements of the largest and the smallest works.

The "Craft" series of welding rods, comprising bronzecraft (for bronze welding steel, brass, copper, cast iron, etc.); Hardcraft (hard surfacing); Ferrocraft (cast iron); Steelcraft (low carbon copper-coated mild steel); Alicraft (for all types of aluminium welding), and Steelcraft stainless for stainless steel.

"Aut-o-Cet" cutting and welding equipment, including hand cutters, welding blowpipes, pressure regulators and accessories.

The "Fluxcraft" gas fluxer which obviates the use of powder flux in bronze welding and leaves no glassy deposit. The acetylene passes through the unit, picks up the flux in vapour form and delivers it to the blowpipe in the gas—the flux is in the flame.

Charles Weston & Co. Ltd., Irwell Bank Works, Douglas Green, Pendleton, Salford, 6, will show fluid sealing devices, including the well-known "Gits" and "Weston" leather oil seals and "Weston" synthetic rubber oil seals. These oil seals can be supplied to most conditions met in the engineering world.

Of particular interest to engineers is the range of "Gits" split oil seals which are available in various forms. All components of the seal can be renewed.

For high speeds and extreme operating conditions there is the "Impax" oil seal which seals axially and is self-adjusting for life. It is a scientifically designed unit and can be supplied complete with contact ring.

Examples of Weston synthetic rubber mouldings will also be displayed.

The theme of the exhibit of **Henry Wiggin & Co. Ltd.,** Birmingham, is the history of nickel since its discovery 200 years ago. The classic papers on which the Company's present products are based will be shown against a background of uses and include the first description of the art of nickel plating, the first patents on nickel-chromium and nickel-chromium-iron alloys, original papers on the production of malleable nickel and the low-expansion nickel-iron alloys and material relating to the introduction of the nickel-copper alloys. Some typical examples of uses of the Company's mill products in nickel and nickel alloys will also be shown. Technical literature will be available.

Wilkinson Rubber Linatex Ltd., Frimley Road, Camberley, Surrey, will show Linatex patented rubber used as the basic raw material for manufacture of abrasion and corrosion-resisting linings in material handling and chemical plant. Model sand and gravel plant, coal loading equipment, sectional tanks, pipes, valves, are on view. Also displayed are the Linatex pump (a single-stage centrifugal type) and the Linatex ball mill (a batch grinding machine), both of which have been designed to utilise to the fullest advantage the special properties of Linatex. Several recent improvements have been incorporated in the equipment displayed as the result of experience in connection with coal preparation plant and pottery production. A wide range of conventional rubber products including gaskets, sealing sections, flexible ducting, anti-vibration mountings and hose are also displayed, all being made from Linatex material.

Williams & James (Engineers) Ltd., Chequers Bridge, Gloucester, will show a selection from a range of various sizes of air compressors and air compressing plants suitable for compressing volumes up to 150 cfm and elevating pressures to 3,500 psi. Single and multi-stage machines will be exhibited. Rotary and vane type vacuum pumps. Starter motors that can be operated by compressed air or cartridges for starting oil and petrol engines. Pressure-reducing valves for air, steam or water. Single-stage, heavy duty, bottle charging compressors.

Wilson & Kyle Ltd., Catherine Wheel Road, Brentford, Middlesex, will demonstrate diesel fuel injection equipment comprising: fuel pumps, fuel valves, fuel valve nozzles, combined fuel pumps and fuel valves for conversion of diesel engines using blast air injection to solid injection.

Precision spares and W. & K. diesel engine pressure indicators will also be exhibited.

Worthington-Simpson Ltd., Newark, Nottinghamshire will show centrifugal pumps. A wide range of self-priming and non-self-priming units of patented "Monobloc" construction, in which the pump and motor are combined as a single unit. Also split casing, end suction and multi-stage centrifugal pumps arranged for electric motor or engine drive. Direct-acting steam pumps. Power pumps of piston and plunger design for hydraulic and general service arranged for electric motor or engine drive. Air compressors for high and low pressures, single and multi-stage models, air and water cooled. Vacuum pumps. Marine pumps of patent self-priming and submersible self-priming types. Non-self-priming circulating and extraction pumps.

THE BORSIG-FIAT MARINE DIESEL ENGINE

(*Concluded from page* 247)

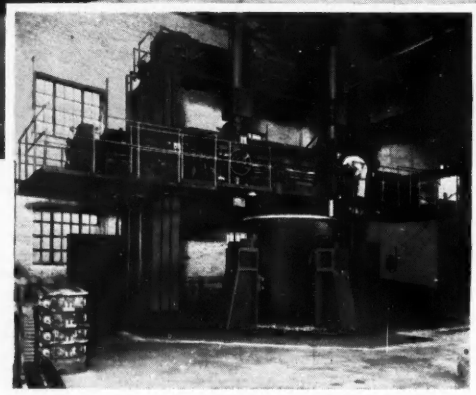
owing to the less favourable shape of the lower combustion chamber, the power of the double-acting engine is only 1·7-1·75 times that of the single-acting engine of the same cylinder dimensions, in spite of its 2-3 per cent better mechanical efficiency. Compared with the single-acting machine, the double-acting engine has a 3-4 per cent higher fuel consumption, but its weight and space requirements related to those of a single-acting engine of equal power are about 10-15 per cent lower, even when taking account of the greater weight of fuel used.

CONCLUDING REMARKS

The Borsig-Fiat type engines have an average fuel consumption of 170 grammes per metric bhp-hour and their overload capacity is 40 per cent for at least 3 hours. The medium and large bore types will operate satisfactorily on boiler fuels, including bunker oil C, which are 25-30 per cent cheaper than normal fuel. Improved processing methods have been developed for the preparation of the fuel oil, with more rapid and effective centrifuging.

A prevalent view among shipowners has been that, in regard to machinery for ships' propulsion, for powers exceeding 10,000 shp the steam turbine is superior to the diesel engine. It is of interest, therefore, to communicate to all interested parties that the Soc. di Navigazione "Italia" has decided in favour of diesel engines as main engines for two of its large ocean liners: the "Roma" and the "Augustus." The power required is 50,000 hp. Although practical possibilities of comparison were completely lacking for installations of this size, it was nevertheless decided to fit each of these ships with four double-acting Fiat 12-cylinder engines of 650 mm bore. Each engine will have a rated power of 13,500 hp at 165 rpm and 20,000 hp at 195 rpm. The engines are guaranteed to be able to operate on bunker oil "C" type boiler fuel. Thus, the fuel utilisation is improved by approximately 45 per cent and this was a decisive factor in this interesting development.

FABRICATION *in* MILD *and* STAINLESS STEELS



The upper illustration shows a mild steel fractionating column 4ft. inside dia. by 55ft. overall height, the supporting cone flared to 8ft. 10in. dia. in 10ft. Approx. weight 12½ tons.

The inset illustration shows a vertical boring mill recently installed in the Machine Shop at Widnes. The Table is 18ft. 5in. in dia. with a clear height under the crossrail of 13ft. 11in.

The engineering service offered by WIDNES FOUNDRY includes fabrication in mild and stainless steels of specialised plant and equipment for the chemical, gas, oil and allied industries. The fabrication of Coolers, Condensers, Storage Tanks and similar constructional work is the logical parallel to production of cast iron vessels in heat and acid resisting, high duty and alloy irons for the industries mentioned. In foundry work and in fabrication in steel WIDNES offer a skilful comprehensive service to industry.

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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

BLOWERS AND COMPRESSORS

Simplified Design Comparisons of Axial Compressors

By F. L. WATTENDORF. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 18, No. 7, July 1951, pp. 447-459, 14 illustrations.)

THIS paper reports a continuation of studies initiated in 1944 regarding potential improvements of turbo-jet propulsion systems for supersonic flight as suggested originally by Dr. Theodore von Kármán, Chairman of the U.S.A.F. Scientific Advisory Board and Chief Scientific Adviser to the Air Engineering Development Division.

Simplified design comparisons of axial compressors with particular emphasis on the attainment of a high rate of mass flow per unit frontal area are discussed. This feature is important not only in the application of turbo-jets to the propulsion of supersonic aircraft but also in the study of future potential requirements for jet engine component testing and for application to the design of more compact compressor systems for wind tunnels such as those at the Arnold Engineering Development Center.

A comparison is made of some aspects of axial compressor design for accommodating a high rate of mass flow. In particular, the influence of hub ratio and axial Mach number on the stage-pressure ratio based on assumed limitations of all relative and absolute Mach numbers is given for compressor types designed according to various principles such as free vortex flow, rigid body pre-rotation, and arbitrary distribution of rotor work.

The important relationship between maximum temperature rise and mass-flow ratio is derived for several compressor types, so that a general qualitative picture is given of the influence of compressor type on the relationship between temperature rise and mass-flow ratio. This study represents a qualitative method of comparing compressor types and refers to the inlet stage alone, which is usually critical for mass flow.

ELECTRONICS

The Electro-Analogue, an Apparatus for Studying Regulating Systems

By J. M. L. JANSSEN and L. ENSING. (From *Philips Technical Review, Holland*, Vol. 12, Nos. 9 and 11, March and May, 1951, pp. 257-271, 28 illustrations, and pp. 319-335, 30 illustrations, respectively.)

AN electro-analogue is an apparatus with which electrical models of regulating devices can be built-up and studied. The electro-analogue discussed here comprises two special models and one universal model of the process to be regulated, the latter model consisting of an electric network—mainly a delay network—the step-function response of which, displayed on the screen of an oscilloscope, can be given a shape identical to that of any process to be imitated. Further, the electro-analogue comprises electrical models of automatic controllers with continuous action and of certain controllers with discontinuous action. In the model of the continuously acting controller, a proportional term, a single and a double integrating term, and a single and a double differentiating term, can be realised.

After the model of the process has been given the right characteristic, it is combined with one of the models of the automatic controller to form a closed regulating circuit. By applying a step disturbance at a suitable point, it is possible to study with the aid of oscillograms the behaviour of the circuit at different values of the parameters. In particular, the conditions under which instability arises and the degree of quality of the regulation can be investigated. Oscillograms are given for various cases, both with continuously and with discontinuously acting controllers.

In the "planning" of the electro-analogue, the fundamental idea was that it should be possible to obtain any desired combination of parts by plugging-in separate connecting leads. All input and output terminals must, therefore, have the same direct-voltage level. The method usually followed for such a purpose —employing separating capacitors and leak resistors— cannot be considered in this case, because the large number of these R-C couplings which would have to be contained in the control circuit would lead to instability. Instead of these couplings, voltage dividers have been used, which provide for the correct direct-voltage level; not only positive, but also negative supply voltages are needed for this and, moreover, these have to be carefully stabilised.

Among the various parts discussed in this article are: The process analogues, the universal amplifier, the collecting stages, the integrator and the differentiator, models of discontinuously acting controllers, the oscilloscope, the supply, and the mechanical construction.

A Storage Oscilloscope

By L. E. FLORY, J. E. DILLEY, W. S. PIKE, and R. W. SMITH. (From *RCA Review, U.S.A.*, Vol. 12, No. 2, June 1951, pp. 220-229, 13 illustrations.)

WITH the continued increase in operational speed of electronic devices, visual observation of the consequent short-duration and often non-repetitive phenomena produced has become increasingly difficult. Long-persistence phosphors or photography may be used, but they have obvious disadvantages. This paper describes a storage oscilloscope built around a Graphechon electronic storage tube which may be used for viewing such transients. Such a device is shown to offer certain advantages in convenience, speed, flexibility and viewing time over more conventional methods.

The instrument described is still in a state of development and its possibilities have not been fully explored. The purpose of this paper is to present the principle of electronic storage in oscillography as a new tool, in the hope that it may prove a useful device to facilitate the study of transient phenomena.

MATERIALS TESTING

Influence of the Method of Machining a Notch on the Results of Notch Impact Tests

By S. K. MAKSIMOV. (From *Zavodskaya Laboratoriya, Russia*, Vol. 15, No. 8, 1949, pp. 967-971, 2 illustrations.)

THE author first reviews earlier work on this subject and shows that most papers do not contain sufficient information on the applied method for making the notch, and that, in consequence, it is often difficult to

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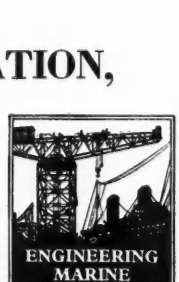

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compare experimental results obtained by various investigators. The author of this paper has examined the influence of the type of machining used for the notch on the results of Mesnager impact tests. The notches were produced by drilling, milling and grinding. A total of 350 test samples was tested under an impact of 30 kgm. From the results obtained it can be seen that the mean values of milling and grinding differ by 3·5 to 9 per cent from the values obtained for drilling. These fluctuations can easily be explained; during drilling, scratches on the notch surface follow a spiral and are less dangerous than scratches caused by milling or grinding, since these occur in the longitudinal direction of the notch.

The author has also investigated the influence of the type of machining used for the notch upon the critical temperature range of brittleness in the case of all three classes of machining on specimens made of 44·6 kg/mm² tensile steel. From the results obtained it can be concluded that grinding does not bring about a change in the critical temperature and in the temperature range in which the steel is brittle and, therefore, grinding represents a suitable method for the production of notch impact specimens. This method is also a very economical one, since (according to Soviet Specifications) the time required for machining by hand is 18 mins., for machining by milling 3 mins., and for grinding 1·8 mins., i.e., the latter is much shorter than for any other class of production of test specimens.

New Devices Speed Metal Fatigue Tests

(From *Technical News Bulletin* of the *National Bureau of Standards, U.S.A.*, Vol. 35, No. 7, July 1951, pp. 103-105, 2 illustrations.)

SEVERAL devices recently constructed at the National Bureau of Standards are proving valuable in speeding metal fatigue tests. The new auxiliary test equipment includes devices for stopping the testing machine when a small crack forms in a specimen, an apparatus for the uniform polishing of fatigue-test specimens, and a machine for fatigue-testing thin sheet specimens in bending.

Fatigue fracture occurs in two stages. In the first stage the metal is subjected to fluctuating stress until a small crack forms. In the second stage, the crack grows until the remaining cross-section of the member is too small to support the applied load, whereupon complete fracture takes place. In fatigue studies it is usually desirable to determine the number of cycles of stress required to start the crack, as well as the number to complete the fracture. These determinations are facilitated if the testing machine can be stopped automatically when a small crack forms.

The surface condition of test specimens has an important effect on fatigue and must therefore be made as uniform as possible. Two pieces of apparatus developed at the Bureau, both entirely automatic, make possible close duplication of the polishing operation from one specimen to the next.

In finishing specimens it is important that the direction of polishing be parallel to the direction of the stress to be applied in the fatigue test. This avoids stress concentration at the roots of the scratches. It is also important that abrasive pressure be light in order to avoid excessive cold-working of the surface. If these requirements are met, the surface need not be extremely smooth or highly polished.

Because of the large deflection required, sheet metal of less than about 0·015-inch thickness cannot be fatigue-tested in bending on commercially available testing machines of the cantilever type. By deflecting the specimen as a column, a newly developed fatigue-testing machine makes possible the bending of specimens to a small radius of curvature without large amplitudes of motion in the driving mechanism. Because the machine holds several specimens at once, considerable testing time may be saved.

PRODUCTION RESEARCH

A Contribution to the Study of Tool Cutting Capacity

By M. COCIGLIO. (From *La Metallurgia Italiana, Italy*, Vol. 43, No. 5, May 1951, pp. 170-176, 11 illustrations.)

THE "cutting capacity" of a tool material is an exceedingly complex feature which depends upon many physical properties, among which the wear resistance at high temperatures must be emphasised. It would be very desirable to express it synthetically by means of only one figure, and primarily to find a simple and inexpensive procedure for its determination.

After a critical review of many procedures derived from Schlesinger's original one, a test procedure based on the "wear at constant speed and path" is proposed. All practical requirements can be met in many cases by such a procedure.

STEAM POWER PLANTS

Mercury Steam Power Plants

By H. N. HACKETT. (From *Mechanical Engineering, U.S.A.*, Vol. 73, No. 7, July 1951, pp. 559-564, 1 illustration.)

THE continued upward trend of fuel and other operating costs is providing the impetus now apparent in the electrical power industry for the use of high-efficiency power cycles. Every effort is being made to produce a kilo-watt-hour with the minimum expenditure of fuel and at the lowest possible cost.

The successful outcome of three new mercury plants has again demonstrated the practicability and economy of the mercury cycle and that it may be applied wherever desired or wherever economically justified. There are numerous types of applications where the mercury-steam cycle may be used to advantage, although most applications usually come under four general types, as follows:—

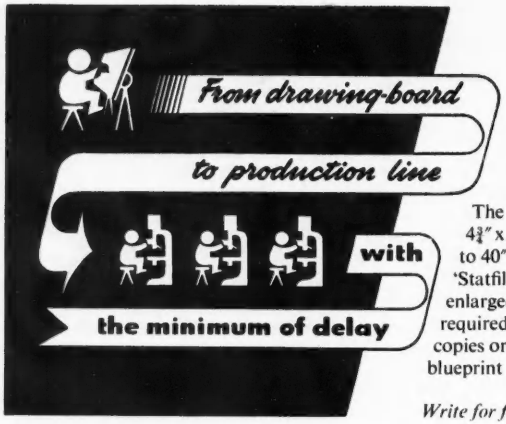
Type 1. Complete condensing plants where only electrical power is produced. Suggested nominal plant capacities would cover the range of from 12,500 kW to 130,000 kW with expected fuel input rates of from 10,500 B.T.U. to some 8800 B.T.U. per net kWhr from the smaller to the larger sizes.

Type 2. Topping plants for topping existing steam generating units, (*a*) where additional electrical generating capacity is required in addition to supplying high-pressure steam to existing steam turbines, the so-called topping plants, (*b*) where additional electrical power and process steam is required for factory process work or for supplying low-pressure steam for central heating systems, and electrical power for general distribution.

Type 3. Mercury-plant installations where an acute shortage of important facilities exists, such as (*a*) deficiency of condensing water, (*b*) insufficient steam boiler capacity and demand for additional electrical generating capacity.

Type 4. For the rehabilitation of otherwise obsolete steam generating plants where (*a*) inefficient or obsolete and defunct steam boilers require replacement, (*b*) where it is desired to increase the over-all power plant efficiency to the maximum, (*c*) where it is desired to increase the plant efficiency, and at the same time add the maximum amount of topping capacity.

Areas of high fuel costs obviously offer the most fertile fields for exploitation of the mercury cycle because of the appreciable reduction in yearly fuel requirements. These fuel cost savings in many cases are in excess of 30 per cent, thereby making the application of the mercury-steam cycle extremely attractive.



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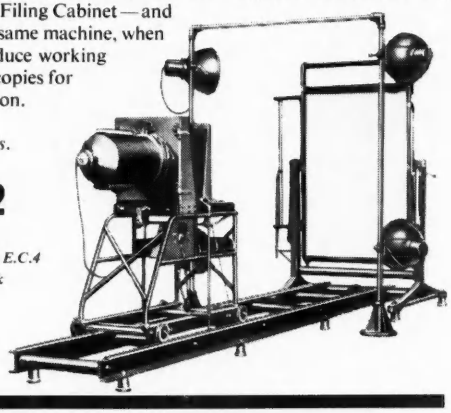

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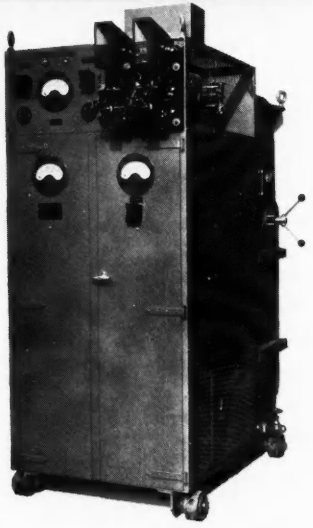

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NEWS OF THE MONTH

PERSONAL

Mr. E. Archer has been elected a director of Brampton Fittings Ltd., Brandwell Road, Oldbury, Worcestershire, an associate company of Walton & Brown Ltd., Downing Street, Birmingham. **Mr. Archer** and **Mr. T. Watson,** works director, have been appointed joint general managers.

Mr. A. J. Beanland, B.Sc.Tech., A.M.I.E.E., A.M.I.P.E., has been appointed assistant general manager of the Trafford Park Works of Lancashire Dynamo & Crypto (Mfg.) Ltd.

Mr. A. J. Bourne, works manager of Earle, Bourne & Co. Ltd., Heath Street South, Birmingham 18, has been appointed a director of the Company.

Mr. A. Cheney, B.Sc., Northern Counties Engineer of Acheson Colloids Ltd., 18 Pall Mall, London, S.W.1, has moved to his new office at 7 Hunters Lane, Rochdale.

Mr. R. H. Chilton, who for many years has been associated with I.C.I. (Alkali Division) Ltd., has joined, as a partner, the firm of G. F. Ward & Partners, consulting engineers, Old Colony House, South King Street, Manchester.

Major C. R. Dibben, director of J. Brockhouse & Co. Ltd., has been appointed by the Chancellor of the Exchequer, to be Chairman of the Midland Regional Board for Industry.

Mr. F. J. Erroll, M.A., A.M.I.Mech.E., A.M.I.E.E., M.P., has removed his office to 21 Alexander Square, London, S.W.3. Tel. Kensington 9543.

Mr. F. B. George, manager, works development, **Mr. H. V. Tomlinson,** manager, works production, **Mr. G. M. Nave,** manager, coke, by-products and brick works, and **Mr. S. Bates,** secretary, have been appointed local directors of the Consett Iron Co. Ltd., Consett, Co. Durham.

Mr. R. A. Harding has been appointed general manager, and **Mr. N. D. Pentland,** sales manager, of Macrome Ltd., Wolverhampton. Mr. P. N. Rogers has been appointed directors' special representative.

The Railway Executive announces the following appointments :— **Mr. J. F. Harrison, M.I.Mech.E., M.I.Loco.E.,** mechanical and electrical engineer, London Midland Region, Derby ; **Mr. K. J. Cook, O.B.E., M.I.Mech.E., M.I.Loco.E.,** mechanical and electrical engineer, Eastern and North Eastern Regions, Doncaster ; **Mr. R. A. Smeddle, M.I.Mech.E., M.I.Loco.E.,** mechanical and electrical engineer, Western Region, Swindon ; **Mr. J. Blair,** carriage and wagon engineer, Scottish Region, Glasgow ; **Mr. H. Randle, M.I.Mech.E.,** carriage and wagon engineer, London Midland Region, Derby, and **Mr. G. T. Smithyman, A.I.Mech.E.,** executive officer for carriage and wagon production, Derby.

Mr. I. S. Horabin has been appointed sales manager of Scottish Mechanical Light Industries Ltd., Scot. Mec. Works, Ayr. Mr. J. A. Culley has been appointed liaison officer.

Mr. Frank Arnold Hurst has been elected chairman of Samuel Osborn & Co. Ltd., Clyde Steel Works, Sheffield, in succession to **Mr. Samuel Eric Osborn,** who died on July 19th, at the age of 59.

Mr. Barry Kaye, Midland Regional Controller of the Board of Trade, C.M.L. Building, Great Charles Street, Birmingham 3, has been appointed to act in the Midlands for the newly formed Ministry of Materials.

Sir Frederick Leith-Ross, G.C.M.G., K.C.B., and **Mr. Jean Louis,** President of the Societe Francaise des Constructions Babcock & Wilcox, Paris, have been elected to the Board of Babcock & Wilcox Ltd., Farringdon Street, London, E.C.4.

Mr. A. J. C. MacLeod, A.M.I.E.E., Assoc.M.C.T., has been appointed export manager of Lancashire Dynamo & Crypto (Mfg.) Ltd., and will operate from the company's London office, 94 Petty France, London, S.W.1. **Mr. V. W. Press** has been appointed sales manager for the London area.

Mr. A. H. Marsh, A.M.I.E.E., has been appointed generation engineer (construction) in the South East Scotland Division, and **Mr. G. R. Peterson, B.A., M.I.E.E.,** has been appointed generation operation engineer in the Chief Engineer's Department of the British Electricity Authority.

Mr. J. W. Martin, sales manager of Whessoe Ltd., Darlington, has been appointed a director of the Company.

Mr. G. C. R. Mathieson, B.Sc.(Glas.), D.R.T.C., has been appointed senior lecturer at the School of Gas Turbine Technology, Farnborough.

Mr. H. M. Mustill, secretary, and **Mr. E. Jones,** sales manager, have been appointed directors of Towler Brothers (Patents) Ltd., Rodley, Leeds.

Mr. F. M. Owner, chief engineer of the engine division of the Bristol Aeroplane Co. Ltd., is leaving shortly. He will be succeeded by **Dr. S. G. Hooker,** deputy chief engineer of the Company.

Mr. F. J. Pepper, has been appointed executive officer (wagons) at the Headquarters of The Railway Executive.

Wing-Commander H. P. Powell has joined the Lockheed Hydraulic Brake Co. Ltd., Leamington Spa. His responsibility will be to promote closer liaison with the aircraft industry.

Mr. J. B. Scott, D.F.C., A.I.E.E., general sales manager of the plant division of Crompton Parkinson Ltd., Aldwych, London, W.C.2, has been elected an executive director of the company. He will take up a new appointment as assistant sales director (home) on October 1. **Mr. C. A. J. Martin, G.C., M.C., B.A., A.M.I.E.E.,** product sales manager, F.H.P. motors, has been appointed general sales manager, and **Mr. R. V. Powditch, O.B.E., A.M.I.E.E.,** sales manager F.H.P. motors.

Mr. G. F. Sly has been appointed assistant works manager, and **Mr. J. Kirkpatrick,** chief designer of United Ebonite and Lorival Ltd., Little Lever, near Bolton.

Dr. P. F. Soper, B.Sc.(Eng.), M.I.E.E., has been appointed Head of the Electrical Engineering Department of the Northampton Polytechnic, St. John Street, London, E.C.1, to succeed **Dr. S. J. Tait** who has been appointed Principal of the Woolwich Polytechnic. **Mr. Kenneth J. Hume, B.Sc.(Eng.)** has been appointed Head of the National College of Horology and Instrument Technology at the Northampton Polytechnic, St. John Street, London, E.C.1.

Mr. F. J. Stephens has been appointed managing director of the Anglo-Saxon Petroleum Co., Ltd., and of the Shell Petroleum Co. Ltd., St. Helen's Court, London, E.C.3, and a delegate member of the Board of N. V. de Bataafsche Petroleum Maatschappij, Hague.

Sir James Swinburne, F.R.S., who was Chairman of Bakelite Ltd. from its inception until 1948, has resigned his directorship. In recognition of his long and valued services he has been appointed Honorary President to the Company. **Mr. C. C. Last** and **Mr. G. W. Hodds,** joint general managers, **Mr. P. Huffman** and **Mr. N. H. Docker** have been elected to the Board.

Mr. B. E. Terry, A.M.I.Mech.E., has been appointed technical manager of the Plastics Division of E. K. Cole Ltd., Southend.

Mr. J. W. Wicks, M.I.Mech.E., has been appointed works manager ('buses and coaches), **Mr. J. Schofield, M.C.,** works manager (tramways and trolleybuses) at Charlton and Fulwell works, **Mr. N. H. Charles, B.Sc., M.I.Mech.E., A.M.I.E.E.,** planning and methods engineer (road services works), **Mr. W. D. D. Brewer, M.Com.,** progress and materials superintendent ('buses and coaches), **Mr. L. F. Hoeniss, A.M.I.P.E.,** chief inspector (road services), and **Mr. R. I. D. Arthurton, B.Sc.(Eng.),**

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Mr. R. J. B. Woodhams, B.Sc.(Lond.), A.F.R.Ae.S., M.I.A.S., has been appointed assistant chief designer to Air Service Training, one of the Hawker Siddeley Group of Companies, at Hamble, Hampshire. He will be responsible to **Mr. H. W. Sidwell, O.B.E., A.F.R.Ae.S.,** the chief designer, for the design section of the aircraft division.

The British Electricity Authority announces the following appointments:—**Mr. W. Wilde, B.Sc., A.M.I.Mech.E., A.M.I.E.E.,** chief generation engineer (operation) of the London Division, in succession to **Mr. H. J. Bennett, A.M.I.E.E.,** who has been appointed Controller of the South Wales Division; **Mr. R. E. Cornish, A.M.I.E.E.,** system operation engineer, Midlands Division; **Mr. J. Whitfield, A.M.I.Mech.E., A.M.I.E.E.,** generation engineer (operation) in charge of No. 3 sub-division of the North-Western Division, in succession to **Mr. O. S. Woods,** who has been appointed chief generation engineer (operation), East Midlands Division; **Mr. Ernest Long,** secretary of the Authority, in succession to Mr. H. F. Carpenter, who is retiring.

BUSINESS NOTES

A New "Series II" Coulthard Madison-Kipp Model 400 Hi-High Pressure Die Casting Machine is now manufactured by Wm. Coulthard & Co. Ltd., Carlisle. Many new features have been incorporated in this machine, amongst them a system of telemotor control, through which an increase of the output up to 50% can be achieved. The new control system allows the operator to stop the die carriage in any position.

The die holding power of the machine has been increased to 82 tons (183,600 lbs.) and the injection pressure on the metal has been stepped up by more than 50%.

Other new features include a new totally enclosed power unit which reduces fire risks to a minimum, yet is readily accessible; automatic shutdown in case of a pressure drop in the hydraulic system; completely redesigned main valve block with easily replaceable valve units and new type packings; and a new oil filter, housed in an independent filter tank.

Powell Duffryn Carbon Products Ltd. and **Great Lakes Carbon Corporation** of New York announce an agreement under which a jointly owned Company, British-American Carbon Corporation, has been formed in the United States to manufacture and sell carbon and graphite, and a wide range of carbon and graphite products used principally by the chemical, metallurgical and other processing industries.

The new Company will be the sole producer in the United States of carbon and graphite manufactured directly from coal by the Powell Duffryn "Delanium" process and its products will include the specialities developed by Powell Duffryn Carbon Products Limited, in this country, such as the Powell Duffryn Cubic Heat Exchanger, "Paragrid" Carbon Scrubbing Towers and Tower Packings and other products.

Mr. William J. Crawford, formerly of Great Lakes Carbon Corporation, has been elected President of the new Company, whose offices will be situated initially at 18, East 48th Street, New York, N.Y.

Matterson Ltd., Rochdale, makers of Gearboxes, Electric Hoists and Overhead Travelling Cranes, have transferred their Midland Representation to The Barnol Engineering Co. Ltd., of 83, Newhall Street, Birmingham 3. (Tel. No. Cen. 2760), a new associate company of Inspecting Engineers Ltd., who have been Matterson's Technical Representatives for some years. Continuity of customers' interests will thus be secured.

Santon Ltd., Newport, Mon., has moved into a large new factory at Somerton. **Mr. G. G. Burton** has been appointed works manager of the new factory, and **Mr. R. J. Trevelyan** has become manager of the firm's County Works factory. **Mr. J. C. Sanders** will assume responsibilities as works director of the two factories.

The Hydraulics Research Organisation, Department of Scientific and Industrial Research, requests that all correspondence for Sir Claude Inglis and the Organisation should be addressed to The Director, Hydraulics Research Station, Howbery Park, Wallingford, Berkshire. The telephone number is Wallingford 2381.

Large Promotion Campaign for the 1952 B.I.F. The wide representation of British industry expected at the 1952 B.I.F. is one of the major points in the overseas promotion campaign launched by the organisers this year. The story of Britain's Shop Window, with its coverage of 90 separate industries, will be told in 26 languages by means of advertisements in the leading newspapers and trade journals of the world, in booklets, on showcards. More than 10,000,000 posters, poster stamps and other media of publicity will be distributed throughout the world in the Fair's 1952 campaign. Some 280 United Kingdom government posts overseas will co-operate with British commercial interests in securing distribution of publicity material and information. Special advance issues of the B.I.F. catalogues, giving descriptive details of exhibitors' products, cross-referenced in eight languages, will be available for consultation by overseas buyers well before the Fair opens.

More intensive promotion in North America, which has been confined to the U.S.A. for the past two Fairs, will this year be extended to include Canada, an export market which is assuming ever greater importance in Britain's economy.

From a sample of bookings already made in London and Birmingham for the 1952 B.I.F. it is apparent that a considerable proportion of exhibitors regard the B.I.F. as offering unique opportunities for the smaller firms as well as for the larger, established companies.

WORLD METALLURGICAL CONGRESS

More than 145 major American metal-producing industrial plants in 13 states and 57 cities will open their doors this Autumn to 250 visiting top-level metal scientists from Marshall Plan and other non-communist nations, providing them with an opportunity to scrutinize closely United States metal production methods and to compare at first hand their own operations.

The scientists will visit the American concerns during a series of eight, four-week study tours in September and October.

The study tours, which start September 17, are preliminary to the scientific sessions of the World Metallurgical Congress to be held in Detroit, Michigan, October 14 to 19.

Behind these industrial visitations lies a broad analysis of world metal resources and their conservation and proper utilization by the free nations.

Dr. Zay Jeffries, Director General of the World Metallurgical Congress and William H. Eisenman, Executive Secretary of the American Society for Metals, have arranged the industrial itineraries.

Visiting conferees, as the scientists are called, will meet with thousands of American metal engineers and technical men who will attend the World Metallurgical Congress, as well as the 33rd National Metal Exposition being held concurrently. An estimated 35,000 members of the American and Canadian metal industries will visit Detroit at that time.

The following corporations and organizations are among those open to Study Tours: United States Steel; Bethlehem Steel; Timken Roller Bearing; Ford Motor; American Brass; Dow Chemical; Pratt & Whitney; Cincinnati Milling Machine; Chrysler; International Harvester; General Motors; Rensselaer Polytechnic; Westinghouse; Pullman; Nash-Kelvinator; U.S. Navy Laboratories; Great Lakes Steel; Armour Research Foundation; Carnegie Institute of Technology; Massachusetts Institute of Technology; National Bureau of Standards in Washington, D.C.; and universities of Harvard, Illinois and Columbia, among others.

1951 DESIGN CONGRESS

The first international discussion by industrialists of their Design Policies will take place at the Royal College of Art in London on September 19th and 20th as an official event of the Festival of Britain. This "Design Congress" will be attended by about 250 invited guests, mainly chairmen, directors and managers from leading firms in Britain, Europe and the U.S.A. They will discuss the topic "Design Policy in industry as a responsibility of high level management."

In many industries at home and abroad, Design Policy is recognised today as a function of business management comparable in importance with Production, Marketing and Advertising Policies; but so far there has been little opportunity for firms to pool their experience and talk over their common problems. Members of the Congress will meet concurrently in three groups and will listen to and discuss papers on their own and related industries. These have been prepared by 23 prominent industrialists from Britain and overseas.

Small exhibitions of photographs and other material illustrating the Design Policies of the speakers' firms will be staged in the Royal College of Art.

The Congress has been planned by the Council of Industrial Design, which appointed a Management Committee with representatives from the Federation of British Industries, the Trades Union Congress, the Royal Society of Arts, the Society of Industrial Artists and the Design and Industries Association.

FREIGHT HANDLING

The Anglo-American Council on Productivity, 21 Tothill Street, London, S.W.1, has now published the Report of the British Team which made its visit to the U.S. with Marshall Aid, on U.S. methods.

Commenting on the general high level of commodity production, the Report states that America impresses the visitor as a country where almost anything the human mind can envisage can readily be obtained if the money is available. The average American constantly strives for the things on offer, and it may be is urged on by his womenfolk, who want articles which—though to the ordinary British housewife unattainable luxuries—are in common use in the U.S.

In methods of freight handling, no startling difference in the standard of achievement in the two countries was apparent, but the visit to the U.S. revealed important variations in technique, in the attitude of mind to mechanization and in the degree to which particular methods, common to both countries, have found favour in one more than the other.

Apart from particular refinements and gadgets and the use of the drag-line—a continuous chain, either overhead or under the floor, to which are attached, as required, four-wheeled trolleys—no types of mechanical equipment were seen which are not in general use in Britain, but there was much wider application and more intensified use. It was not possible to compare accurately the relative speed of working or cost per ton of handling freight, but the visitor to the U.S. is immediately conscious of a high degree of enterprise, keenness and industry displayed by management and staff in their daily work—particularly in road transport.

The Team was particularly interested in the use of pallets in transport. In factory, depot and dock operation, palletisation on permanent pallets was found to be highly developed—"Keep the

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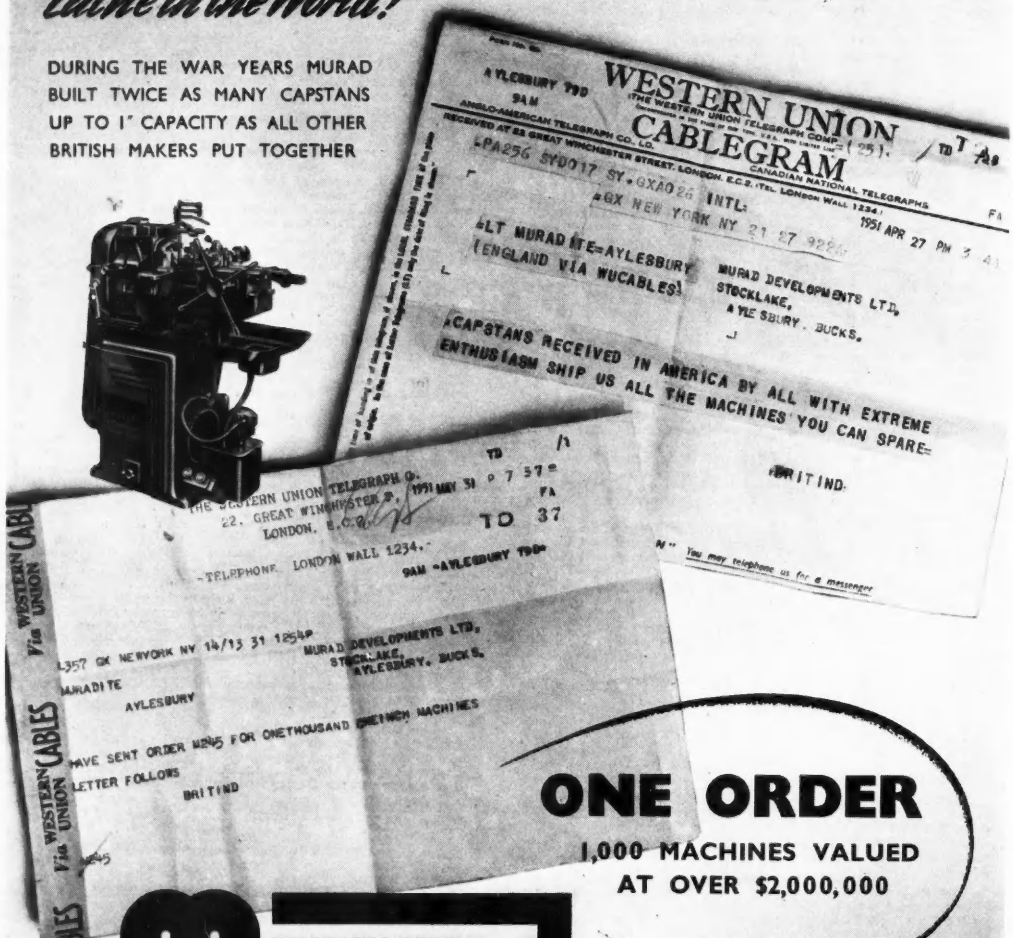

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goods off the floor " was the dominant aim—but the proportion of traffic palletised for the complete transport operation in comparison with the total amount available was surprisingly small. There are many reasons for this (p. 12) and it is pointed out that peace-time operations involve different problems from those solved in the complete palletisation of American equipment and supplies used in the D-Day build up.

As a result, there is a keen search in the U.S. for ideal types of expendable (one-trip) pallets which need not be returned, but the Team points out that, as this device would entail a not inconsiderable consumption of relatively expensive materials, its general adoption by British traders in present circumstances is unlikely.

Particular emphasis is laid on the potentialities in general transport use afforded by :

(i) Fork-truck operation, either with pallets or, for suitable traffics, pusher or specialised attachments on the fork trucks ;
(ii) The development of palletisation and the unit load for throughout transport ;
(iii) The drag-line method of mechanising transport depots.

There should be the widest possible dissemination and exchange of information and experience on freight-handling methods.

The management-labour co-operation on the maximum use of mechanical equipment which prevails in America should be followed energetically in all phases of freight handling in Britain.

LANDING CATERPILLAR-WISE

A caterpillar undercarriage has been fitted to an *Auster* aircraft. It allows the light plane to take-off and land from small rough airfields.

In place of the ordinary two-wheel undercarriage, it has eight light-weight wheels, a set of four each side, each set connected by an endless rubber belt. Each wheel has independent suspension.

When the aircraft is taxi-ing or landing on a rough airfield, the long light-weight caterpillar track bends itself into the shape of the ground. It absorbs shock much more easily and the weight is distributed over eight wheels instead of the conventional two. Landings on a rough airfield can be made in about three-fifths of the normal distance and the *Auster* can make a much firmer landing when coming into a small airfield across the wind.

SBAC FLYING DISPLAY & EXHIBITION

Britain's latest aircraft and aero-engines—a total of more than 50 different types—will be at the 1951 SBAC Flying Display in September. Work is being speeded on some of the latest designs which have not yet flown, in the hope that they will be airborne in time for exhibition.

About 20 of the aircraft, most of them jets, will be making their first public appearance. The new types will give flying demonstrations every afternoon—including the days when the Display is open to the public, 15th and 16th September.

Some of the world's fastest fighters will be on show for the first time, and so will the R.A.F.'s new four-jet bomber—perhaps the world's fastest bomber. Other new fighter prototypes destined for R.A.F. and Navy service will be there, alongside Britain's fleet of civil gas-turbine airliners which are now opening up the world's first jet air routes.

Four delta-wing research aircraft—" flying triangles "—are to be on exhibition, and some of them will be giving aerobatic displays. The public will be able to inspect the *Brabazon*, the world's largest civil landplane, which will be parked alongside small two-seat trainers and helicopters.

The speeds of these machines illustrate the wide range of planes on show. They run from 50 miles-an-hour backwards by helicopters in reverse to around the speed of sound for the latest fighters. Landing speeds range from 40 miles-an-hour for lightplanes to 120 miles-an-hour for some high-speed aircraft.

The Display will be at Farnborough, Hampshire. Tuesday, 11th September is the Technicians' and Press pre-view day and is NOT open to the public. Wednesday, 12th September is the official opening day, when, as on the two following days, the Display is open only to guests invited individually by the Society. On Saturday and Sunday, 15th and 16th September, the whole Display and Exhibition will be thrown open to the public. A special attraction on these two days will be a display of R.A.F. jets in formation, arranged in collaboration with the Royal Air Force as part of the Battle of Britain celebrations. This jet formation display will be fitted into the Flying Display in the afternoon.

NINE FACTORIES BUILD BRITISH JET ENGINE.

Plans are going ahead for setting up seven different production lines for the Rolls-Royce *Avon* jet engine—six of them in Britain. So far as is known, this is the largest-scale production of any single jet engine in the world.

Rolls-Royce are building the *Avon* at Derby and are also planning to start production at two factories in West Scotland, Hillington and East Kilbride. Two other engine companies are to build the *Avon* : Bristol and Napier. Napiers are opening up a factory at Bootle, Lancashire, especially for the Rolls-Royce jet. The motor-car industry has also been called in to help in *Avon* production. The Standard Motor Co. has completed plans for turning some of its Coventry factory space over to building *Avons*.

The *Avon*, rated at 7,200 lb. thrust, and one of Britain's most powerful axial-type engines, is installed in the latest fighter interceptors, the newest light bomber (the *Canberra*), and in the R.A.F.'s new four-jet *Valiant* bomber.

The Australian-built *Avon* will power the *Canberra* and the American *F-86 Sabre*, which is to be built in Australia and at at present has a less powerful engine.

MANUFACTURE OF WILKERSON VALVES IN GREAT BRITAIN.

Exactor Ltd., 108 Park Street, London, W.1, who are the sole concessionaires for the British Commonwealth and Europe for the Wilkerson valves at present being marketed in the U.S.A., are shortly to undertake their manufacture in Great Britain. British patents are pending.

The range comprises automatic separators and drains for compressed air lines, automatic sump and after-cooler drains for all sump applications, automatic tank drains for stationary compressors, lorries, buses, and railway locomotives, air governors and governor filters for the actuation of air-operated devices and airbrake-equipped lorries and buses, as well as accessory fittings for installation of the valves. Some of the main features are outlined below.

The separators and drains for compressed air lines are diaphragm-operated valves for interrupted flow installations or float-operated valves for interrupted and continuous flow installations. The diaphragm-operated valves automatically remove oil, water, grit, rust sludge and other contaminants from compressed air lines, and combine the principles of centrifuge, impingement, directional and volumetric variations, separating all contamination from compressed air as it flows through the valves to air-operated equipment. These valves are fully automatic, require no manual attention, and operate with remarkably low pressure drop. With only one moving part, these units are designed for years of trouble-free service under all operating conditions.

The float-operated line separators and drains produce large volumes of drier, cleaner air with no significant pressure drop. These valves remove contamination from compressed air in the same manner as the diaphragm valves just described, but are designed for use on larger-size lines and for high volume.

The automatic sump drain unit (float-operated) automatically drains accumulations from line sumps, tanks and after-coolers. It is not designed to separate contamination from compressed air. The float mechanism in this unit operates exactly as the mechanism in the float-operated line drains just described.

The Wilkerson automatic tank drain for stationary compressor tanks automatically drains water and all foreign matter out, saves air of the air receiving tank, reduces service and repair on the compressor, and has a long-life construction. Thousands are already in use in the U.S.A.

The Wilkerson air governor is actuated by pressure differential, in the compressed air receiver, changing the direction of air flow which produces high-pressure intermittent line connection, for use in actuating or controlling air-operated devices. There are also special filter models for air compressor-equipped lorries and buses, incorporating a filter specially designed to prevent gumming of oil fumes, sludge or grit in the ball seat of the governor.

BOOK REVIEW.

Der Ultraschall. (Ultrasonics). 5th Edition. By L. Bergmann. Publishers : S. Hirzel Verlag, Zürich, 1949. Price, Swiss Francs 50.—

Since the first edition of this book was published in 1937, interest in the science and technology of ultrasonics has increased enormously and it is not surprising, therefore, that former editions of this book,

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published by V. D. I. Verlag, Berlin, are no longer available. This, however, is due not only to the development of ultrasonics as a useful tool to physicists, chemists and engineers, but also to its value in the biological and medical field. Bergmann's book was soon generally accepted as a textbook on the subject and as such has no rival. The latest edition has been completely revised and enlarged in the light of recent developments and contains a most useful bibliography of some 2000 references to research papers, articles, and other publications on the subject. The number of illustrations and tables has been greatly increased and we can recommend this book, without reservation, not only to specialists in and students of the science of ultrasonics, to whom it should prove to be of outstanding value, but also to those who like to broaden their general knowledge. They will find the subject as fascinating as the author's presentation of it.

BRITISH STANDARDS

(*Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.*1.)

Micrometer Heads B.S. 1734 : 1951 relates to micrometer heads supplied independently for assembly with measuring tools or machine tools and applies to three types, having measuring ranges of ¼ inch, 1 inch, 13 mm. and 25 mm. and thimble diameters below 1 inch, 1 inch and below 2 inches, and 2 inches and over. General requirements for the component parts of the head are given and dimensions, graduations and standards of accuracy are prescribed. Price 2/-.

Bevel Protractors, Optical and Mechanical B.S. 1685 : 1951 relates to three mechanical types and one optical type of bevel protractors. Standards of accuracy are prescribed for the body, stock and blade of the protractor and for the acute angle attachment, when provided.

The method of graduating both types is specified, and general requirements in respect of material, workmanship and marking are included. Price 2/-.

Alternating-Current Relays for Railway Signalling B.S. 1745 : 1951 applies to alternating-current line and track relays of the induction type intended for use in railway signalling circuits not exceeding 250 volts, and is applicable to relays with or without a local element. Price 2/-.

Cast Iron Smooth Tube Economisers with Pressed Socket Joints B.S. 1713 : 1951 covers cast iron smooth tube economisers with pressed socket joints having a maximum water design pressure up to and including 325 lb./sq. in. (gauge) where the socket joints are not reinforced, and a corresponding maximum pressure of 475 lb./sq. in. (gauge) where the socket joints are reinforced in accordance with the requirements of this standard.

In the section dealing with Construction, formulae are included for determining the design pressure for economiser sections with pressed socket joints : minimum thicknesses of headers, tubes, and manifold pipes. Formulae for determining flange dimensions and the number of bolts and studs to be used are also given. The minimum sizes of studs required for certain pressures are laid down and also the minimum lengths for the tapped holes. Installation requirements are specified together with details of the mountings. Inspection during construction is also stipulated together with details of hydraulic tests. Price 2/-.

Flanged Cast Iron Gate Valves Classes 125 and 250 for The Petroleum Industry. (B.S. 1735 : 1951). It covers flanged cast iron gate valves with either wedge gates or double disk gates and having either outside screw-and-yoke rising stems or inside screw non-rising stems, the seat rings being either separate or an integral part of the body wedge or disks. The permissible pressure is a maximum of 400 lb/sq. in. for liquid and gas at about atmospheric pressure and 250 lb/sq. in. for saturated steam for valves 14-24 in. size.

It includes provisions relating to design and manufacture, materials, workmanship, marking, tests, inspection, despatch, and guarantee.

The specification is supported by a number of appendices and four detailed drawings illustrating the valves covered and providing identification of the various parts of the valves. Price 5/-.

B.A. Screws, Bolts, Nuts and Plain Washers (B.S. 57 : 1951). General dimensions for all the common types of B.A. screws, bolts and nuts in sizes 0 B.A. to 16 B.A. are included and the ranges of nominal sizes, given in the tables are classified as "Preferred," "Second choice" and "Not normally stocked." Tables relating to each type of screw and showing the lengths in which each size is normally stocked and other lengths which may be regarded as standard, although they are not normally stocked, are also included.

General requirements in respect of material, screw threads and finish are given and dimensions are specified for two types of washers. Price 3/-.

Classification of covered electrodes for the metal-arc welding of mild steel and of medium-high-tensile steels of welding quality. (B.S. 1719 : 1951), classifies electrodes according to the method of manufacture, type of flux covering, welding positions in which the electrode can be used, welding current conditions and whether or not the electrode is suitable for deep penetration welding. It sets out a coding system consisting of a prefix letter and a three digit number by which the classification of the electrode on the above criteria can be conveniently indicated. The suffix letter "P" is used to indicate electrodes suitable for deep penetration welding.

An appendix gives useful information on the characteristics of various types of flux coverings. Price 2/6.

The Nickel Bulletin, Vol. 24, No. 4. The number of new technical papers published on Spheroidal-Graphite cast iron indicates the increasing interest on the part of metallurgists and engineers in this relatively new development. The current issue of the Nickel Bulletin includes extended abstracts of three important papers on this material ; one reviews the present stage of development with representative mechanical properties and typical applications ; the second and third deal in some detail with various types of heat-treatment. A further abstract on new materials for gears includes a review of the properties of ductile cast iron, indicating its potential value in this field and also describes the use and manufacture of "Nitralloy N" a 3½% nickel-chromium-molybdenum steel with an addition of aluminium.

Applications of nickel-containing materials in the gas turbine result in continuing interest in creep-resistant properties at high temperatures and abstracts of several useful and important papers on this subject are also included.

Other abstracts present up-to-date information on the properties of nickel alloys and describe other well-established applications in a wide range of industries.

Copies may be obtained on application to :—The Mond Nickel Co. Ltd., Sunderland House, Curzon Street, London, W.1.

High Nickel Alloys for Heat-Resisting Equipment. The remarkable heat-resisting properties of nickel and of its alloys with chromium and iron are well known. On heating in air, these alloys develop adherent oxide films with refractory properties which prevent the progressive oxidation and scaling experienced with steel and many non-ferrous materials.

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Copies of the above publication can be obtained free of charge on application to :—Henry Wiggin & Company Limited, Wiggin Street, Birmingham 16.

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